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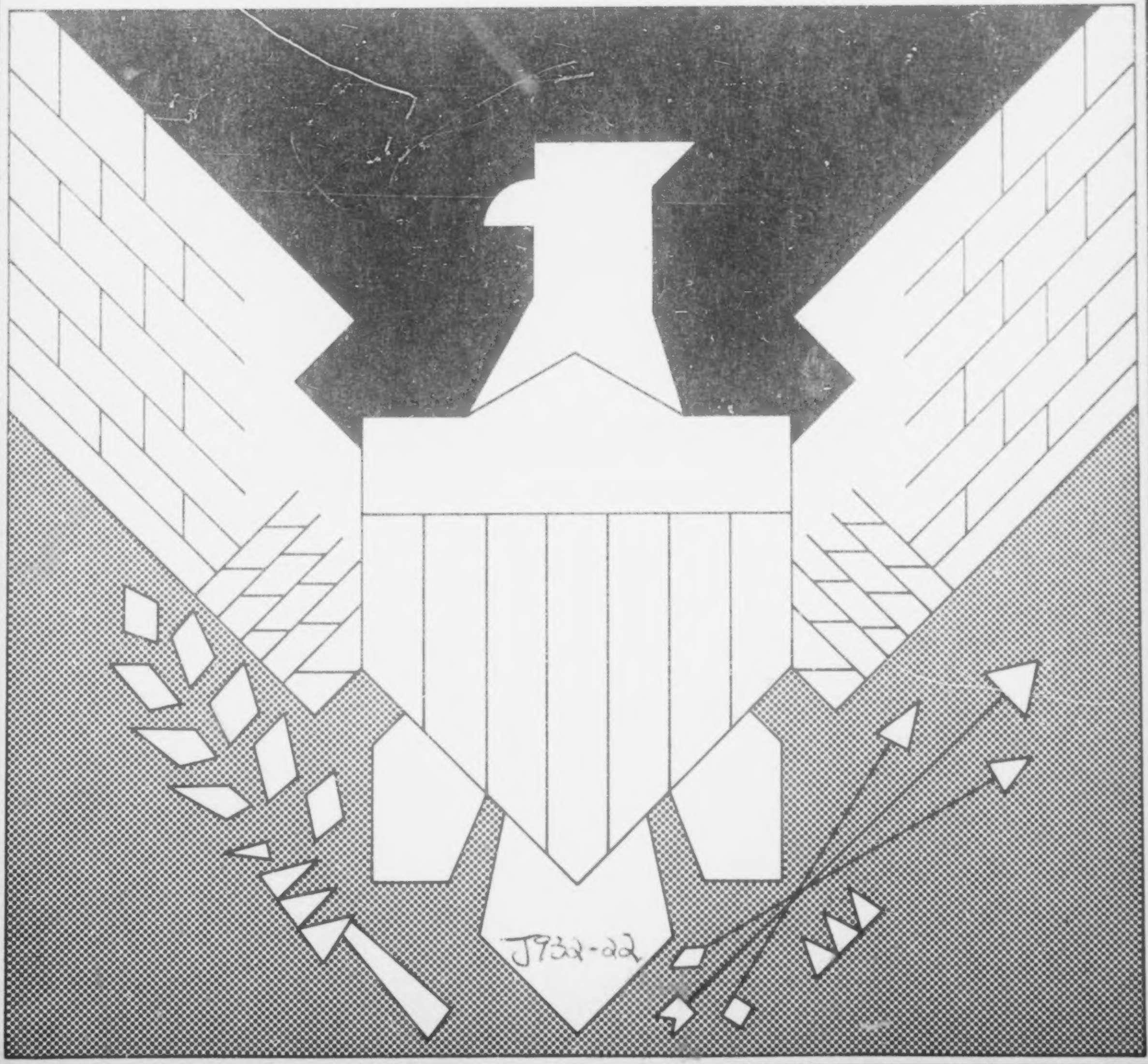
U.S. Ground Forces and the Conventional Balance in Europe



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CBO STUDY

U.S. GROUND FORCES AND THE CONVENTIONAL BALANCE IN EUROPE

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Congressional Budget Office

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NOTES

Unless otherwise indicated, all years referred to in this report are fiscal years.

Unless otherwise indicated, all dollar amounts reflect budget authority in constant fiscal year 1989 dollars.

Details in the text, tables, and figures of this report may not add to totals because of rounding.

PREFACE

The conventional balance in Europe between the forces of the North Atlantic Treaty Organization and the Warsaw Pact has been the topic of widespread debate since the two alliances were formed shortly after World War II. The recent agreement between the United States and the Soviet Union to eliminate the entire class of intermediate-range nuclear weapons has focused attention on the relative standing of the conventional forces that remain in Europe. Many suggestions have been made in recent years as to how to improve NATO's standing in relation to the Warsaw Pact, including numerous proposals for increasing the capability of NATO's ground forces. Yet the Congress, faced with budgetary constraints, must consider the cost of those options as well as their benefits. This study by the Congressional Budget Office, performed at the request of the House Committee on Armed Services, first assesses the current standing of NATO relative to the Warsaw Pact, with emphasis on each alliance's ground forces. The study then examines both the benefits and the costs of alternatives for improving the capability of NATO's ground forces. In keeping with CBO's mandate to provide objective analysis, the study does not recommend any particular course of action.

Frances M. Lussier of CBO's National Security Division prepared the study with the extensive assistance of Elizabeth A. Chambers and under the general supervision of Robert F. Hale and John D. Mayer, Jr. William P. Myers and Raymond J. Hall of CBO's Budget Analysis Division assisted with the cost analysis included in the study. The author gratefully acknowledges the helpful suggestions provided by Roberton Williams and Jeffrey A. Merkley of CBO and Dr. James R. Blaker of the Hudson Institute. (The assistance of external participants implies no responsibility for the final product, which rests solely with CBO.) Sherry Snyder edited the report, and Rebecca Kees and Kathryn Quattrone prepared it for publication.

James L. Blum
Acting Director

June 1988

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SUMMARY

Deterrence of war in Europe--or, if necessary, its successful prosecution--is a key goal of U.S. defense strategy. Achieving that goal depends in part on the balance of conventional forces between the United States and its allies in the North Atlantic Treaty Organization (NATO) and the Soviet Union and its Warsaw Pact allies. (Conventional forces include all military forces other than those employing nuclear weapons.)

Assessments of the conventional balance of military forces in Europe depend on many highly uncertain assumptions. Adding to the uncertainty is the contribution of nuclear weapons, which are thought to deter both sides from starting a war. Uncertainties notwithstanding, the Warsaw Pact has more weapons than NATO, particularly more heavy weapons like tanks. NATO's conventional forces also suffer important vulnerabilities. Some analysts believe those vulnerabilities will be heightened after intermediate-range nuclear forces (INF) have been eliminated under the terms of the recently enacted treaty or if long-range nuclear weapons are reduced under future treaties.

These concerns have led to proposals for improving NATO's conventional military capability. The improvements could cost tens of billions of dollars, a matter of concern in this period of fiscal restraint. Thus, it is important to understand how much such improvements would add to costs and capability, and to determine the status of the conventional balance of forces that these proposals seek to alter.

ANALYTIC METHOD AND ITS LIMITATIONS

This study assesses the balance of conventional ground forces and options to alter that balance by using, as a primary measure, a technique known as the WEI/WUV method (for weapon effectiveness indices/weighted unit values). This technique accounts not only for the quantity of weapons but also their quality and judgments about the importance of each type of weapon in ground combat. The WEI/WUV method computes the capability of each type of ground-combat unit relative to the capability of a U.S. armored division. These measures of capability can then be summed for all the forces on each side to produce a ratio of Warsaw Pact forces to NATO forces. A ratio of greater than one suggests an advantage for the Pact and vice versa.

Like all such techniques, the WEI/WUV method has important limitations. First, the method can only be used to evaluate the "static" balance--that is, it cannot, without extensive modification, take into account factors that affect the conduct of war, such as losses of weapons or personnel. Rather, it is useful for assessing the relative position of two forces before a war starts. Second, it evaluates the contribution of weapons but not support equipment. Third, the WEI/WUV method cannot quantify such intangibles as training, morale, or leadership. Finally, it does not incorporate the potential contributions of tactical aircraft to either side's capability. The method's inability to capture the contributions of NATO's support forces and tactical aircraft may understate NATO's capability relative to that of the Warsaw Pact. NATO invests more heavily in support equipment and personnel than does the Pact, and NATO's aircraft and pilots are generally thought to be more capable than their Pact counterparts.

As a secondary measure used primarily to assess the impact of several options for improving NATO's ground forces, this study relied on a dynamic method developed by Joshua Epstein of the Brookings Institution. Epstein's model attempts to simulate the loss of both forces and territory during the conduct of war. A dynamic analysis of the actual conduct of war was particularly important for assessing some of the options for improvement that are designed to alter the course of combat. Like the static method, Epstein's model does not capture the contribution of support equipment; nor can it account for either side's morale, leadership, or training. It does, however, attempt to simulate the contribution to the ground war made by each side's tactical aircraft.

CONVENTIONAL BALANCE OF MILITARY FORCES

Because of the limitations of all analytic methods, any comprehensive assessment of the balance of military forces in Europe involves military judgment. This study, however, cannot offer such an assessment. Instead, it provides perspective by analyzing the balance of ground forces in Europe's central region under a variety of assumptions. (The central region is normally assumed to include the Federal Republic of Germany, the German Democratic Republic, Belgium, the Netherlands, Luxembourg, Poland, and Czechoslovakia.) Three sets of assumptions, outlining three cases, formed a basis for this study:

- Assumptions Favorable to NATO (Case 1). The amount of time NATO takes to respond to a Warsaw Pact mobilization for war is critical. Under the most favorable circumstances, NATO begins its mobilization without delay. Who mobilizes and fights is also important. Again, the most favorable assumptions would have all the NATO allies, including France, mobilize and fight immediately; Poland and Czechoslovakia, two Pact allies, would not mobilize at all. Finally, this case assumes that the least prepared Soviet divisions take a long time--up to 90 days--to become fully operational.

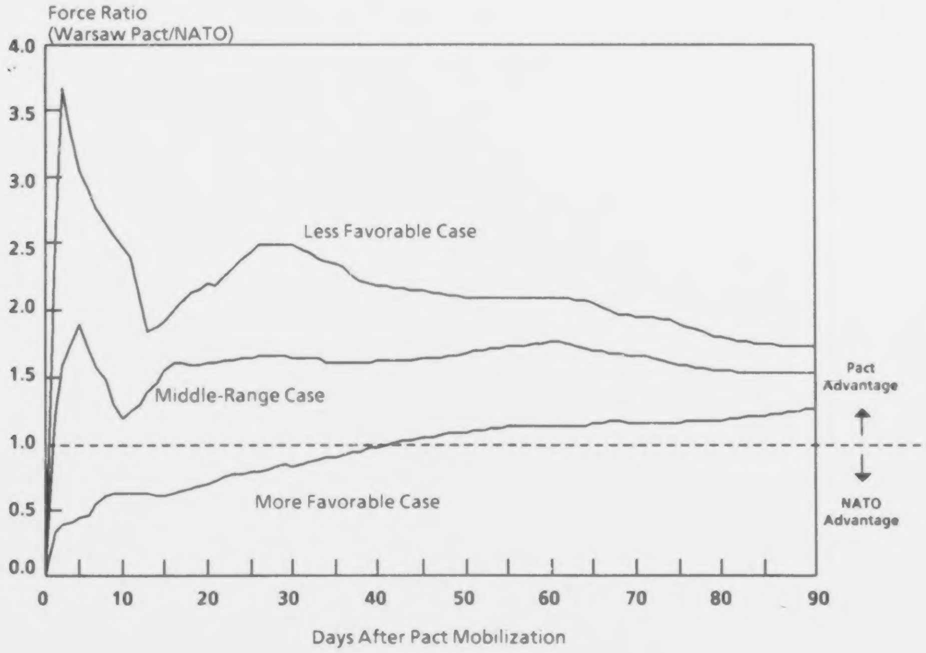
- Assumptions Less Favorable to NATO (Case 2). Any delay in responding to a Pact mobilization favors the Warsaw Pact and thus is less favorable for NATO. This case assumes that it takes a full week for NATO to respond. Also, it assumes that France chooses not to mobilize, but the Soviet allies, Poland and Czechoslovakia, participate. Finally, this case assumes that the least prepared Soviet divisions require only 25 days to become operational.

- Middle Range of Assumptions (Case 3). This case assumes that NATO does not respond immediately to Pact mobilization but does so four days later. Furthermore, in this case all allies on both sides would mobilize, including France for NATO and Poland and Czechoslovakia for the Warsaw Pact. Finally, it assumes that all of the least prepared Soviet divisions can become operational within 60 days.

Results

The ratios that result from the WEI/WUV analysis of the balance vary widely (see Summary Figure 1). Under assumptions favorable to NATO, the ratios never exceed 1.3 within the 90 days following Pact mobilization. Under assumptions less favorable to NATO, the ratio initially reaches a high value--above 3.7--two days after mobilization and always exceeds 1.7 throughout the 90 days following Pact mobilization. In the middle-range case, the ratio varies between 1.5 and 1.7 following the first 15 days after mobilization.

Summary Figure 1.
Force Ratios in the European Central Region



SOURCE: Congressional Budget Office based on Department of Defense data and on William P. Mako, *U.S. Ground Forces and the Defense of Central Europe* (Washington, D.C.: Brookings Institution, 1983).

What significance can be attributed to these ratios? They cannot be used to predict who will win or lose. The preceding discussion of the shortcomings of the static method underlines the many important factors that are not taken into account. Rather, the ratios that result from the analysis can be used to identify those conditions under which NATO might be at risk.

NATO assumes that the Warsaw Pact will be the attacker. Many defense experts feel that an attacker must attain a ratio of 3 to 1 or 4 to 1 or more in a local area in order to overwhelm the defender, who has the advantage of selecting the point to defend. There is less agreement about the theaterwide ratios necessary to achieve such a localized ratio. Maximum theaterwide ratios that experts believe will not exceed NATO's ability to repel an invasion fall, for the most part, between 1.2 and 2.0.

By this standard, the assumptions favorable to NATO (Case 1) show NATO in a strong position relative to the Warsaw Pact. The results under assumptions less favorable to NATO (Case 2) look bleak. The ratios resulting from the middle-range assumptions (Case 3), which have been used in studies conducted by the Department of Defense in the past, show an advantage for the Warsaw Pact. But the ratios in this last case hover within the range of values that suggest a stalemate. Moreover, the wide range of outcomes represented by all three cases, coupled with the impossibility of knowing which assumptions would materialize in a conflict, suggest that neither side could be confident of victory in the event of war.

Nonetheless, NATO's conventional defenses have some vulnerabilities. NATO's defensive capabilities are not evenly spread over the central region of Europe. For example, the northern part of this region is defended by countries whose units, compared with those of the United States and some other allies, are equipped with fewer and, in some cases, less capable weapons. If the Warsaw Pact concentrated its superior numbers of well-equipped units in one of NATO's more vulnerable sectors, the force ratios would be of concern. For example, even under the middle range of assumptions, ratios in some northern areas could exceed 3, which might encourage the Pact to attack. A breakthrough by Warsaw Pact forces in one geographic area could jeopardize the defense of all of NATO.

Thus, NATO may need to improve its theaterwide forces, or at least avoid any decline, to increase confidence that it could deter the Warsaw Pact from attacking. More important, NATO would be strengthened if it shored up some of its weaker sectors.

ALTERNATIVES FOR IMPROVING THE BALANCE OF CONVENTIONAL GROUND FORCES

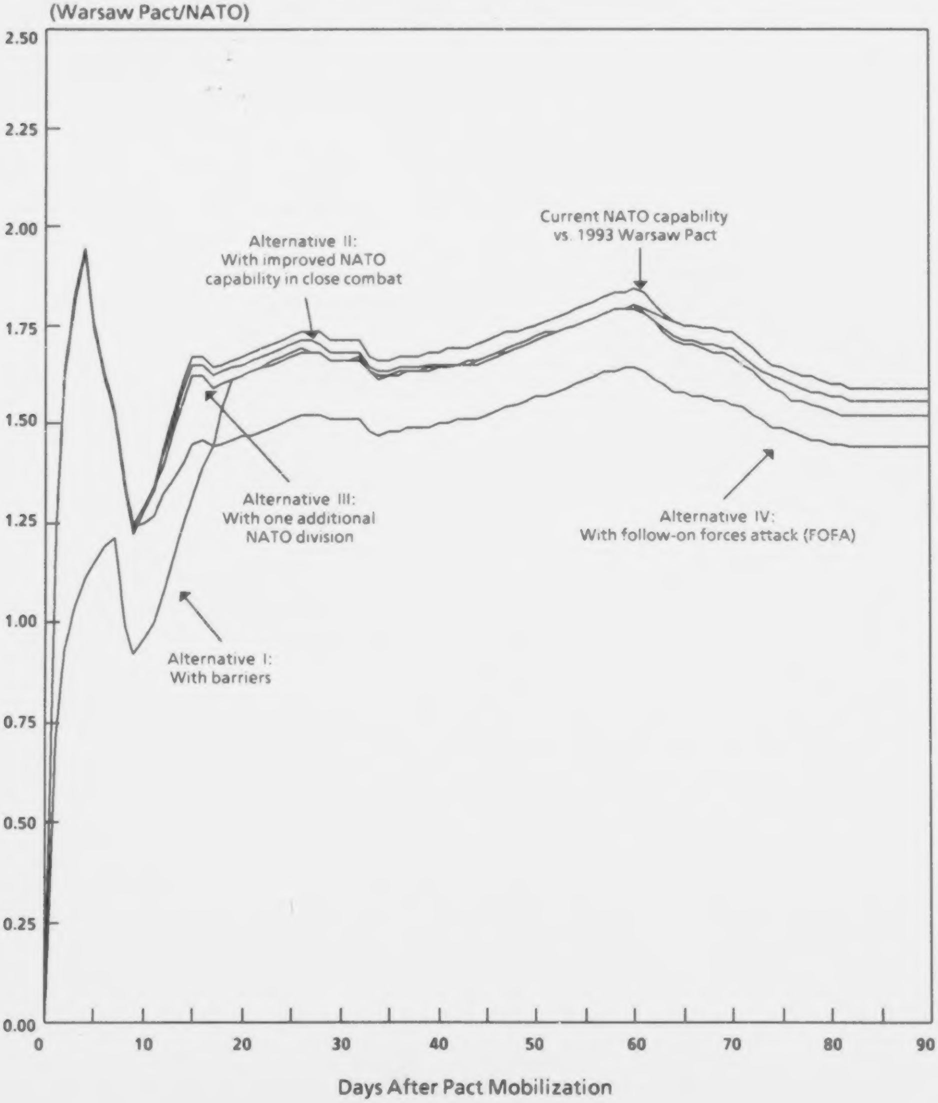
This study analyzed four alternatives for improving the capability of NATO's ground forces. The first three options would improve capability in the early 1990s, whereas the fourth would require longer-term investment and probably not improve NATO's capability until the end of the next decade at the earliest. Only those options that could be carried out by the United States alone, or with minimal investment by NATO allies, were considered since the United States cannot control investments made by its allies.

Alternative I: Construct Barriers Along the Inter-German Border

This alternative examines the benefits that could accrue to NATO from erecting barriers along the inter-German border to slow a Pact attack. Barriers could include steep slopes planted with trees, or ditches created in time of war by detonating previously buried pipes filled with explosives. Although such barriers will not stop a Pact invasion, they could slow the advancing troops enough to provide NATO with precious time to position its forces throughout the theater and to bring up reinforcements.

The quantitative effects of such barriers are difficult to assess, particularly using a static measure like the WEI/WUV method. Both the static and dynamic analyses suggest, however, that barriers would have their greatest effect in the first few days after mobilization, possibly reducing the Pact/NATO force ratio by 20 percent at a point 10 days after Pact mobilization. (Analysis of the alternatives' effects, which is shown in Summary Figure 2, always uses the middle range of assumptions discussed above.) An advantage of this alternative is that estimates of costs are relatively low--ranging from $700 million

Summary Figure 2.
Comparison of Force Ratios Under Four Alternatives for Improving NATO Conventional Ground Forces



SOURCE: Congressional Budget Office based on Department of Defense data; John C.F. Tillson IV, "The Forward Defense of Europe," *Military Review* (May 1981), p. 66; and Office of Technology Assessment, *New Technology for NATO: Implementing Follow-On Forces Attack* (OTA-ISC-309, June 1987).

to $5 billion, depending on the extent of the defensive barrier and support network (see Summary Table 1). Political costs could be higher, however, since barriers raise environmental concerns and also emphasize the existence of two German nations.

Alternative II: Improve NATO's Capability in Close Combat

NATO's overall military capability could be enhanced by providing U.S. forces with the most modern and sophisticated weapons for ground combat currently available. This alternative would buy, among other things, more M1A1 tanks, Bradley fighting vehicles, Apache attack helicopters, and Multiple Launch Rocket Systems. The total cost of implementing such a program, including acquisition and operating costs through the year 2008, could be as high as $48 billion.

SUMMARY TABLE 1. TOTAL COSTS OF ALTERNATIVES FOR IMPROVING NATO CONVENTIONAL GROUND FORCES (Costs in billions of fiscal year 1989 dollars of budget authority)

	1989	1990	1991	1992	1993	Subtotal 1989-1993	1994-2008	Total 1989-2008
				Near Term				
Alternative I: Add Barriers	1.0	1.0	1.0	1.0	1.0	5.0	0.0	5.0
Alternative II: Improve Close-Combat Capability	4.6	5.9	7.4	6.9	4.5	29.4	19.1	48.4
Alternative III: Add One Division	5.0	4.5	1.8	1.8	1.8	14.8	26.4	41.2
				Long Term				
Alternative IV: Emphasize Follow-On Forces Attack	0.6	0.8	0.9	1.1	2.4	5.7	44.0	49.7

SOURCE: Derived by the Congressional Budget Office based on data included in Department of Defense publications; John C. F. Tillson IV, "The Forward Defense of Europe," *Military Review* (May 1981), p. 66; Institute for Defense Analyses, *Follow-On Force Attack*, R-302, vol. V (Alexandria, Va.: IDA, April 1986); and Department of the Army, U.S. Army Concepts Analysis Agency, *Forward of the FEBA Weapon System Cost and Benefit Study (FOFEBA), Phase I*, CAA-SR-81-3 (February 1981).

Purchase of improved equipment for U.S. forces would result in only a 2 percent reduction in the theaterwide force ratio. This relatively small improvement is partly a result of the Army's recent modernization effort, which has already improved many of the U.S. forces that would fight in a European war. Also, since this alternative involves changes only in U.S. forces, which provide roughly half of NATO's total combat units, the effect is diluted. Nor would this approach augment NATO's more vulnerable units to any greater degree, since the improvements would occur in the relatively stronger U.S. forces.

The Administration and the Congress may well pursue this option in order to keep open weapons production lines that would be important in wartime and to increase the capability of selected units that contribute heavily in the later months of a European war. But this approach would not significantly enhance the conventional balance in the key initial months.

Alternative III: Add Forces to NATO

Rather than replace some of its weapons with more modern versions, NATO could improve its conventional capability by adding more ground forces. Having more NATO divisions could alter the conventional balance in Europe in NATO's favor. Because it is not possible to ascertain precisely how many additional forces would deter a Warsaw Pact attack, this alternative would add one division to the U.S. active forces--the most that could be equipped and supported for roughly the same cost incurred under the previous alternative.

This study's methods show that, for equal cost, investing in an additional division has about the same effect on the Pact/NATO balance as modernizing existing divisions. Specifically, this alternative would reduce the Pact/NATO force ratio by 2 percent 60 days after the Pact mobilizes--the same improvement that resulted from the previous alternative. While both alternatives involve roughly the same costs, this alternative would require the addition of at least 16,000 personnel to the active Army. Such an addition would run counter to current U.S. Army plans, which call for reductions in the number of personnel and units.

Alternative IV: Emphasize Attack of Follow-On Forces

Another, quite different approach to improving the conventional balance would expand current plans to acquire weapons designed to delay, disrupt, and destroy Pact forces before they come within shooting distance of NATO forces. This strategy--called follow-on forces attack (FOFA)--would improve the Pact/NATO force balance at the front by delaying or destroying some of the Pact's reinforcement units. Because weapons to accomplish the FOFA strategy are still in development, this approach would not improve capability substantially until well into the next decade. For the same reason, this option involves substantially greater risk than the previous three approaches.

FOFA weapons systems would be designed to destroy bridges and railroads deep in Pact territory and to seek out and destroy Pact units as they move from their own territory to the battlefront. If they perform as designed, such weapons could improve the balance of ground forces at the front both by destroying Pact forces and by delaying those that survive. Using dynamic analyses, and assumptions about potential capability that are conservative relative to those in other studies, this study found that FOFA could reduce the theater-wide ratio by 11 percent at a point 60 days after mobilization. Stated another way, the impact of attacking the Pact's follow-on forces would be equivalent to adding five armored divisions to NATO.

The FOFA strategy also could help shore up all of NATO's sectors. It would help most if FOFA weapons were deployed by all the allies. But even if they were deployed only in U.S. units, the attacks on bridges and railroads deep in Pact territory would disrupt all arriving units, not just those heading for U.S. units. Moreover, the missiles designed for FOFA have ranges sufficient to allow U.S. units to aid neighboring corps.

The total cost to develop and buy the munitions and systems needed for FOFA and to operate them through the year 2008 would be about $50 billion, a slightly larger investment than that required for either Alternative II or III. The bulk of these funds would be needed in the mid-1990s and thereafter, once the weapons for FOFA have been developed and tested.

Despite its potential advantages, FOFA is risky. The estimated costs could increase, which often happens as weapons approach the point of deployment. Political opposition from NATO allies and the Warsaw Pact countries, who view FOFA weapons as destabilizing, also poses problems in realizing FOFA's potential. Since most of the necessary systems are still under development and have had recent program delays, they may not be available to NATO for attacking Pact follow-on forces until later in the 1990s.

Finally, many technical and operational questions remain. Sensors needed to detect enemy units moving toward the battlefront could be attacked by the enemy, thereby diluting their effectiveness or requiring expensive defenses. Moreover, the weapons used to destroy enemy forces before they arrive at the battlefront are sophisticated and have not yet been tested under realistic conditions; they might not work at all, or at least not nearly as well as planned.

Comparison of the Four Alternatives

Though hard to measure, adding barriers has a positive effect on force balance, especially in the early days of a conflict. Given their relatively low cost, barriers would probably be a good investment if political obstacles can be overcome.

Analysis of the other three options suggests that, if it can be made to work for roughly the estimated cost, FOFA offers the greatest payoff. But FOFA is risky because it relies on weapons that have not yet proven their capability or cost. Thus, the Congress may want to combine one or more near-term strategies with continued development of FOFA at a pace that is slow enough to allow careful testing. Emphasis could shift to FOFA weapons when and if their feasibility becomes better established.

CHAPTER I

INTRODUCTION

One of the key defense goals for the United States is to deter, or if necessary counter with military force, an attack in Europe. The United States is joined in this effort by the 15 other members of the North Atlantic Treaty Organization (NATO), which since 1949 has been committed to treating an attack on any member nation as an attack on all members. The potential adversary in a European war is the Warsaw Pact, an alliance formed in Warsaw, Poland, in 1955 among seven nations, the principal one being the Soviet Union. The effectiveness of peacetime deterrence, and of wartime efforts, depends in part on the balance of military forces between NATO nations and those in the Warsaw Pact.

FACTORS RAISING CONCERN ABOUT THE CONVENTIONAL BALANCE

Military leaders and defense experts have recently expressed concerns regarding the balance of forces in Europe, focusing attention on the adequacy of NATO's conventional forces to deter Warsaw Pact aggression. (Conventional forces include all military forces except those employing nuclear weapons.) In particular, former NATO Supreme Commander General Bernard Rogers has stated that although NATO continues to improve in capability, the Warsaw Pact forces improve faster and so "Every year ... the gap continues to widen."[1] James Schlesinger, former Secretary of Defense, and Congressman Les Aspin, Chairman of the House Committee on Armed Services, have also expressed concerns about the Warsaw Pact's superiority in conventional forces.[2] Still other defense analysts, such as Phillip A.

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1. Christopher Redman, "Battle of the Bean Counters," *Time* (June 15, 1987), p. 33.

2. David Fulghum, "Draft Revival Predicted If Nuclear Weapons Are Banned," *Army Times*, December 15, 1986, p. 3.

Karber of the BDM Corporation, feel that recent Soviet weapons developments have fundamentally shifted the balance in the Warsaw Pact's favor.[3]

Several factors underlie most concerns about the balance of forces in Europe. These factors include the Pact's numerical superiority, the growing sophistication of Soviet weapons, and recent technological breakthroughs in Soviet weaponry. Concerns have also been expressed regarding the impact of potential arms control agreements on NATO's ability to deter aggression and, as a consequence, on the existing conventional balance. The recently negotiated treaty on Intermediate-Range Nuclear Forces (INF) has, perhaps, increased the importance of NATO's conventional forces. These same concerns could be heightened further if significant reductions were made in U.S. long-range nuclear weapons as a result of a new far-reaching treaty with the Soviet Union.

Numerical Superiority of the Warsaw Pact

Discussions of the conventional balance in Europe often focus on the number of weapons, troops, or combat units available to each side. Such comparisons invariably give the advantage to the Warsaw Pact. (The quantitative holdings of both NATO and the Warsaw Pact are discussed in detail in the next chapter.) NATO historically has attempted to offset the Pact's numerical superiority by fielding more sophisticated weapons. Many analysts feel, however, that weapons fielded recently by the Soviet Union are beginning to erode NATO's lead in weapons technology. In their annual statement for fiscal year 1988 on U.S. military posture, the U.S. Joint Chiefs of Staff, for example, assessed the relative position of the United States and the Soviet Union in 20 basic weapons technologies. The assessment shows that the Soviet Union equals U.S. sophistication in only six areas, but notes trends that indicate an improvement by the Soviet Union in 9 out of the 20 technologies examined.[4] To some analysts, these trends indicate an erosion of NATO's technological superiority.

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[3] Benjamin F. Schemmer, "An Exclusive AFJ Interview with Phillip A. Karber," *Armed Forces Journal International* (June 1987), p. 112.

[4] Joint Chiefs of Staff, *United States Military Posture for FY 1988* (1987).

Another issue of concern to some defense experts is the possibility of a Soviet technological breakthrough that would negate some of NATO's sophisticated weaponry. A striking example of a potentially significant Soviet breakthrough is the recent equipping of Soviet tanks with a special kind of added armor, called "reactive armor," designed to counter some of NATO's antitank missiles.[5] Some analysts, most notably Phillip Karber, have stated that the fielding of this relatively simple protective measure, first fielded by the Israelis in the late 1970s, could reduce the effectiveness of 95 percent of NATO's infantry antitank missiles. A serious degradation of NATO's antitank capability would certainly have a significant impact on today's balance of conventional forces in Europe.

NATO is, however, working on ways to counter this latest Soviet advance, and the U.S. Army feels that it can modify its missiles to do so. In addition, the United States has developed new uranium-enhanced armor for its tanks to make them less vulnerable to enemy antitank weapons. In short, this episode is only an example of the constantly seesawing relationship between one side's technological advances and the other side's reactions to them. It does, however, illustrate the concerns of many people within NATO regarding the vulnerability of NATO's technical advantage.

Arms Control Issues

Recent trends in arms control have heightened concerns over conventional forces. In part as a response to the Warsaw Pact's acknowledged numerical edge in conventional forces in Europe, NATO has deployed nuclear weapons for use in a conflict, should its conventional forces fail to stop a Pact invasion. Some public officials and defense experts have expressed concerns regarding NATO's ability to continue to deter Soviet aggression without the intermediate-range nuclear weapons that would be eliminated by the INF treaty--a situation that could be exacerbated if the United States' long-range nuclear arsenal

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5. Reactive armor consists of small boxlike structures mounted on the outside of a tank or other armored vehicle. These boxes are constructed so that they explode on receiving a strong blow. Thus, when a projectile, such as an antitank missile, hits one of the boxes, the missile's forward momentum will be disrupted by the outward explosion of the reactive armor. Relatively slow-moving missiles, such as the U.S. TOW antitank missile, would be more adversely affected than very fast-moving projectiles, such as tank rounds.

is reduced by a START treaty (so named after the ongoing Strategic Arms Reductions Talks). Strategic weapons do, to some extent, affect the relationship between NATO and the Warsaw Pact because, even in the absence of intermediate-range nuclear weapons, these long-range weapons may deter Soviet aggression in Europe. However, reducing the nuclear weapons available to NATO in general, and to the United States in particular, could focus even more attention and place more pressure on NATO's conventional forces.

FACTORS FAVORABLE TO NATO

Not all analysts agree that the Warsaw Pact has the conventional superiority necessary to assure victory, should it decide to invade western Europe. The prestigious International Institute for Strategic Studies concluded, after an evaluation of the relative standing of NATO and the Warsaw Pact, that the "conventional military balance is still such as to make general military aggression a highly risky undertaking for either side."6/ Senator Carl Levin, after a recent examination of 13 factors that affect the conventional balance, concluded that NATO actually excelled or equaled the Warsaw Pact in 7 of the 13 categories.7/

Arguments that the INF treaty might place an undue burden on NATO's conventional forces can also be countered. Even though the treaty will eliminate ground-launched nuclear weapons that can attack targets at ranges between 500 and 5,500 kilometers, other nuclear weapons will still be based in Europe. Numerous nuclear weapons that could be employed in the event of a NATO/Warsaw Pact confrontation would remain on both sides. NATO will retain almost 3,000 cannons capable of firing nuclear shells, about 1,500 aircraft capable of delivering nuclear bombs, and more than 500 nuclear ballistic and cruise missiles deployed on submarines and surface ships. Furthermore, individual member nations of NATO have plans to increase and improve their national nuclear arsenals over the next few years.

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6. International Institute for Strategic Studies, *The Military Balance, 1986-1987* (London: IISS, 1986), p. 225.

7. Senator Carl Levin, *Beyond the Bean Count* (report to the Senate Committee on Armed Services, January 20, 1988).

Indeed, even after an INF treaty is carried out, both sides may have sufficient weapons available to cover the very same targets for which the eliminated weapons were intended.

Despite the lack of consensus on the current conventional balance in Europe, almost all analysts would agree that the Warsaw Pact possesses great military capability that creates vulnerabilities for NATO and warrants improvement of NATO's conventional forces. Congressman Les Aspin has advocated improving NATO aircraft to counter Soviet armored forces and conventional arms control measures to reduce the number of Soviet tanks.8/ A task force within the Department of Defense has recommended developing weapons designed to delay Soviet offensive forces.9/ Secretary of Defense Frank Carlucci, and several other defense experts, have suggested building barriers to slow a Pact offensive.10/

Of course, any new course of action will require funding. Some of the proposals being discussed--if they take the specific forms in this study--could cost a total of $40 billion or more, much of which would be in addition to funds currently planned for the U.S. military. In a period of intense fiscal restraint, it is important to be specific about these approaches, their cost, and their potential contribution to NATO's conventional capability. That is the purpose of this study.

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8. Congressman Les Aspin, "The World After Zero INF" (speech presented to the American Association for the Advancement of Science Colloquium on Arms Control, Arlington, Va., September 29, 1987).

9. Dan Beyers, "Spending for NATO Defense to Change," *Army Times*, February 15, 1988, p. 35.

10. Frank Carlucci, as quoted by the *Washington Post* in "Carlucci Asks 'Creative' Response to NATO," December 1, 1987, p. 23. See also, Robert Komer, "A Credible Conventional Option: Can NATO Afford It?" *Strategic Review* (Spring 1984), p. 35; Congressman Les Aspin, "The World After Zero INF"; and Leon V. Sigal, "No First Use and NATO's Nuclear Posture," in John D. Steinbruner and Leon V. Sigal, eds., *Alliance Security* (Washington, D.C.: Brookings Institution, 1983), p. 108.

CHAPTER II

ASSESSING THE BALANCE OF NATO AND WARSAW PACT GROUND FORCES

There is little question that the Warsaw Pact outnumbers NATO in tanks, artillery pieces, and armored vehicles. It is less clear how this numerical advantage translates into a comparison of Warsaw Pact and NATO military capability. That relationship, generally referred to as the conventional balance of forces, depends not only on numbers but on the quality of weapons and on other factors, such as when and how quickly each side mobilizes for war.

The conventional balance in Europe has long been the subject of much study, analysis, and debate. The quantitative balance between ~~the two~~ sides is a function of so many factors--many of which are impossible for either side to determine with certainty--that predicting the outcome of a confrontation is nearly impossible. Useful insights can be obtained, however, by examining the relative military posture of the two sides.

Although all of the military forces--ground, air, and naval--on each side affect the overall balance, most studies of the conventional balance in western Europe focus on ground forces. This is because an invasion of Europe by the Warsaw Pact implies use of ground forces and because it is very difficult to represent accurately the interaction of air, naval, and ground forces. This study provides a quantitative assessment of the current balance of NATO and Warsaw Pact ground forces and examines the factors that influence it.

TYPES AND DISPOSITION OF MILITARY FORCES

Many types of forces affect the conventional balance in Europe. Most of them are ground forces operated by the armies of NATO and Warsaw Pact countries. These ground forces are organized into units of various sizes (see Table 1). The larger units include brigades, which in the U.S. Army generally have between 4,500 and 5,000 soldiers, divisions that are typically made up of three brigades, and corps that include two or more divisions.

Army ground forces can also be designated as "light" or "heavy." Light units--which include airborne, air mobile, and the newly created light infantry units--rely primarily on soldiers with rifles, portable antitank and antipersonnel weapons, and towed artillery. Heavy units--which include both armored and mechanized units--are outfitted primarily with heavier equipment such as tanks, fighting vehicles, armored personnel carriers, and self-propelled artillery pieces. (For examples of these types of equipment, see the Glossary.) Tanks are tracked vehicles that are well protected against enemy attack and are equipped with various types of guns to destroy enemy vehicles. Fighting vehicles have less armor than tanks and attack other

TABLE 1. COMPOSITION OF GROUND FORCES
(Combat units only)

Unit	Typical Number of Soldiers in U.S. Units	Typical Composition a/
Company	90 to 150	3 platoons
Battalion	550 to 800	3 companies
Brigade	4,500 to 5,000	3 to 5 battalions
Division	10,000 to 16,500	3 brigades
Corps	25,000 to 140,000	2 to 5 divisions

SOURCE: Congressional Budget Office based on Department of the Army data and on CBO, *Army Ground Combat Modernization for the 1980s: Potential Costs and Effects for NATO* (November 1982), p. 59.

NOTE: In addition to the combat units listed, each unit includes administrative and support personnel. For example, in addition to three combat brigades, a typical division will include a sizeable administrative headquarters, a military police company, one or two helicopter battalions, an engineer battalion, an air defense battalion, a combat electronic warfare and intelligence battalion, several field artillery battalions, and finance, medical, supply, and transport organizations. Smaller units will include fewer of these support organizations, while larger organizations, such as a corps, will have even more.

vehicles with guns and missiles. Armored personnel carriers are designed to provide a relatively protected method for transporting soldiers. Artillery is designed to deliver large amounts of ordnance over enemy positions located up to 30 kilometers away.

Both light and heavy divisions include helicopters for transporting cargo and troops and for attacking enemy forces. Attack helicopters are heavily armed and can attack enemy tanks and other vehicles. Antitank weapons are typically missiles and can be carried individually or mounted on trucks or armored vehicles. Rifles and other smaller weapons are designed to be operated by individual soldiers.

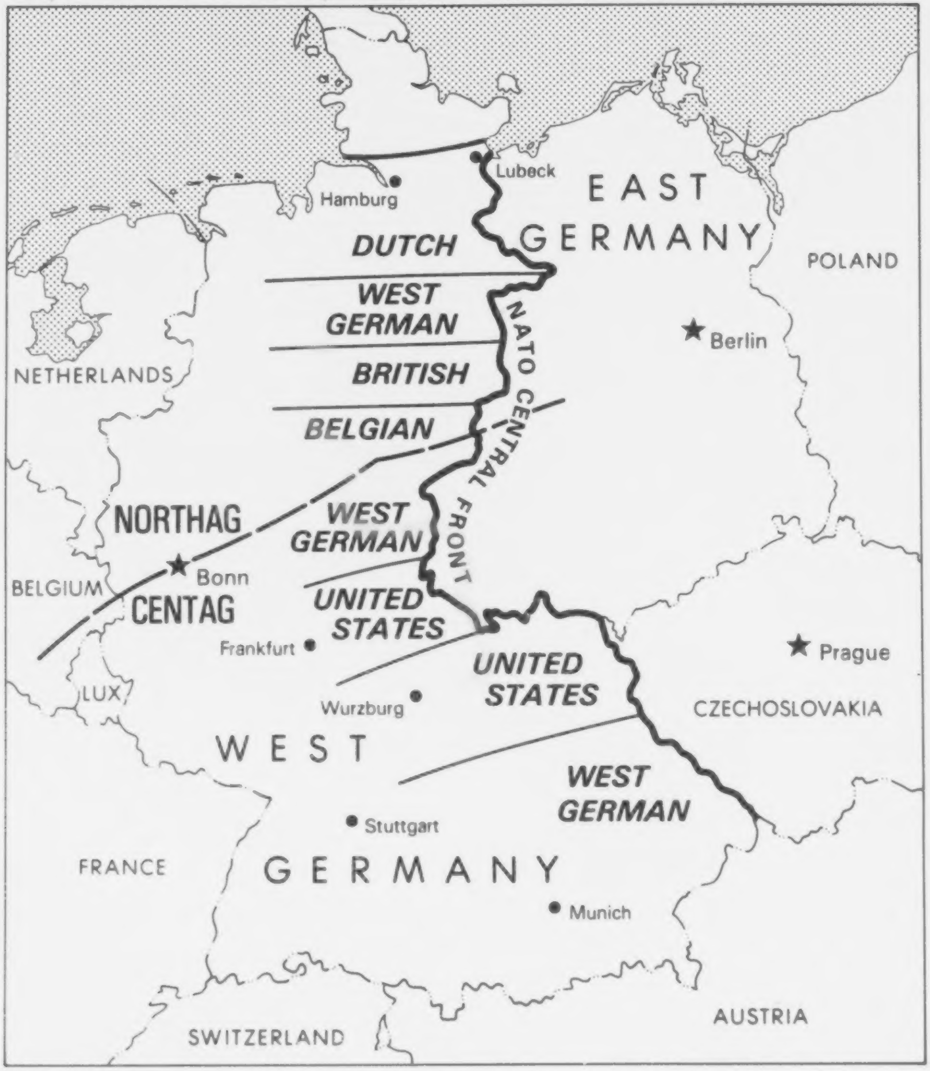
Army ground forces may be augmented by aircraft operated by the Air Force. Usually referred to as "tactical aircraft," some of these planes are designed to repel or destroy enemy aircraft. Others are primarily designed to attack ground installations and destroy enemy tanks or other vehicles.

Disposition of Forces

Forces of these various types are deployed in several regions of Europe. The region of most interest, where the bulk of NATO's assets is located, is called the central region. It consists of an area that stretches for about 800 kilometers along West Germany's eastern border. NATO also has a southern region that includes Italy, Greece, Portugal, and Turkey, and a northern region that encompasses Denmark, Norway, and West Germany north of the Elbe river.

In peacetime, the forces of several NATO countries are deployed within the key central region (see Figure 1). The central region itself is further divided into two military jurisdictions. In the Northern Army Group (NORTHAG), Belgium, West Germany, Great Britain, and the Netherlands each contribute a corps-sized force (two to five divisions). The Central Army Group (CENTAG) comprises two West German and two U.S. corps. Though not assuming responsibility for the defense of any individual corps section, the other NATO members (such as Luxembourg, Denmark, and Canada) could contribute forces as part of NATO's strategic reserve or in defense of their national borders against a Pact attack. (In other words, Danish forces would

Figure 1.
Corps Sectors of Military Responsibility in NATO's Central Region


Lubeck
Hamburg
EAST GERMANY
DUTCH
POLAND
WEST GERMAN
NATO CENTRAL FRONT
Berlin
NETHERLANDS
BRITISH
BELGIAN
NORTHAG
WEST GERMAN
Bonn
BELGIUM
CENTAG
UNITED STATES
Frankfurt
Prague
UNITED STATES
LUX
Wurzburg
CZECHOSLOVAKIA
WEST
WEST GERMAN
Stuttgart
FRANCE
GERMANY
Munich
AUSTRIA
SWITZERLAND

SOURCE: Adapted by Congressional Budget Office from Richard Lawrence and Jeffrey Record, *U.S. Force Structure in NATO* (Washington, D.C.: Brookings Institution, 1974), p. 31, and also from U.S. Army material.

NOTE: NORTHAG (Northern Army Group) and CENTAG (Central Army Group) are the two subdivisions of Allied Forces Central Europe in West Germany. The line dividing the two runs from Belgium through West Germany, just south of Bonn, and into East Germany. The West German corps north of Hamburg is part of Allied Forces Northern Europe.

defend Denmark.) Because France maintains three armored divisions in West Germany, it would presumably contribute forces as well, even though it does not participate in NATO's military council.

In the event of war, the divisions stationed in NORTHAG and CENTAG would be reinforced by units coming from the home bases of the various NATO member nations. Of all NATO reinforcements, one-third would come from the United States. The Department of Defense has therefore established a program to speed the deployment of some of these reinforcements without actually stationing the requisite personnel abroad. This program, which provides storage for "prepositioned" military equipment in Europe for U.S.-based reinforcing units, is known as POMCUS (for Prepositioned Overseas Materiel Configured to Unit Sets).

NUMERICAL COMPARISONS OF FORCES AND WEAPONS

Including indigenous forces, how many combat units of various types are there on each side? Most counts show the Soviet Union dominating the United States and, likewise, the Warsaw Pact surpassing NATO. The 1987 edition of *Soviet Military Power*--a Department of Defense publication--grants the Warsaw Pact an advantage of almost 2 to 1 in divisions, a greater than 2 to 1 advantage in tanks and artillery, and an advantage of 1.3 to 1.0 in tactical aircraft. (The data supporting these ratios are detailed in Table 2.)

Such simplistic comparisons fail to take several extenuating circumstances into account, however. First, some published comparisons, including those in Table 2, do not include any contribution that France or Spain could make to the defense of western Europe. Although not a military member of NATO, France occasionally trains with NATO troops and could contribute up to 15 divisions. And, although Spain could not contribute any combat units to Europe's defense early in a conflict, Spanish troops could serve as reinforcements. Second, the personnel figures cited in Table 2 include military personnel from all services. One could argue that ground forces would be the most crucial in a battle for possession of western Europe, especially those on active duty who are, presumably, the best trained.

TABLE 2. COMPARISON OF WARSAW PACT AND NATO FORCES

	Warsaw Pact	Ratio (Warsaw Pact:NATO)	NATO
Active Personnel	6,000,000	1.3:1	4,500,000
Division Equivalents	230	1.9:1	121
Ground Force Equipment			
Main battle tanks	52,000	2.1:1	24,250
Antitank weapons launchers	28,000	1.2:1	22,580
Artillery, mortars, MRLs	42,000	2.3:1	18,350
Tactical Aircraft	6,550	1.3:1	5,125

SOURCE: Congressional Budget Office using data from Department of Defense, *Soviet Military Power, 1987* (1987), and *Soviet Military Power, 1986* (1986).

NOTE: MRL = multiple rocket launcher.

When a comparison of active ground force personnel is made, including France and Spain on the NATO side and only those forces that would be deployed to the central region on the Pact side, the Warsaw Pact is actually slightly outnumbered--2,385,000 to 2,292,000.[1]

This rough parity in total ground forces in the active military suggests another inadequacy of simply counting the number of divisions available to each side, as was done in Table 2; it ignores differences in their fighting capability. The combined forces of NATO and of the Warsaw Pact include units of varying types and sizes, and equipment of widely varying quality and sophistication. For example, U.S. heavy divisions, nine of which are included in the NATO division total, have an average of over 16,000 soldiers. Soviet tank divisions, on the other hand, typically have only about 10,500 soldiers. The division totals for each side include many units of widely differing design such as highly mobile airborne units that have no tanks at all, and tank divisions that contain approximately 300 tanks. Furthermore, this count mixes active and reserve units without differentiating in terms of quality of people, equipment, or training. (Active forces train constantly during peacetime, whereas in some countries, with the United States being the most prominent example, reserve units train only a few days a month, if at all.) Thus, a simple comparison of 230 Warsaw Pact divisions to 121 NATO divisions provides an incomplete and possibly misleading assessment of the conventional balance of forces.

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[1] International Institute for Strategic Studies, *The Military Balance, 1987-1988* (London: IISS, 1987), p. 231.

The same shortcomings are also true for numerical comparisons of the air forces. The number of tactical aircraft cited in Table 2 include differing numbers of bombers, interceptors, and fighter-bombers. The totals also include aircraft of varying ages and capabilities. Thus, a simple count of aircraft available to each side is as incomplete a picture of each side's capability as are tallies of tanks and divisions.

METHOD OF THE STUDY

Rather than rely on simple counts, this study employs a method that not only reflects the quantity of weapons but also their quality, the timeliness of their arrival in the battle areas, and other factors. To keep the analysis relatively simple and easily understood, the study relies primarily on "static" comparisons. Static methods consider only the total of forces available to each side at a given time; they do not attempt to account for the progress of fighting or combat losses on either side. Such methods can, however, be used to examine how the balance changes as mobilization progresses and more forces become available to each side. In some cases--for instance, when examining the balance of forces in local areas such as corps sectors or after the war starts--dynamic assessments are more appropriate measures. Dynamic methods, which attempt to model the progress of a battle and reflect combat losses, are discussed more fully later in this chapter and in Appendix A.

Static Method

The static method used in this study is based on weapon effectiveness indices (WEI) and weighted unit values (WUV) developed by the U.S. Army. The WEI/WUV method avoids, as much as possible, subjective assumptions concerning the conduct of war. This technique first evaluates and ranks each type of ground weapon--such as a tank, personnel carrier, or howitzer--relative to other weapons of the same type, to arrive at an effectiveness index for each weapon. Weapons are typically evaluated on the basis of their firepower, mobility, and ability to survive an enemy attack. Thus, various types of tanks receive WEI scores and are then ranked against a norm, which for tanks is the U.S. M60A1. For example, the M60A1, as the norm, receives a WEI of 1.00; the M60A3, an upgraded version of the M60A1, an index of 1.11 based on its improved fire control system and power train; and the M1A1, the newest U.S. tank, a WEI of 1.34 because of its overall superiority. Tanks of other nations are scored relative to the M60A1 in the same way. Each category of weapons, such as tanks, artillery or armored personnel carriers, then receives a relative weighting, or WUV score, based on its contribution to the unit's overall performance of its mission in either an offensive or defensive posture. As one would imagine, tanks receive a relatively high WUV factor (94 for defensive operations in Europe), and weapons such as individual rifles receive a lesser weight (3.7).

The total WEI/WUV score for an entire unit, such as a division, can be calculated using these factors. To arrive at the unit's total score, each weapon's index is multiplied by the appropriate weighting factor and all the products are totaled. The score for each combat unit, such as a U.S. light infantry division or a Soviet motorized rifle division, is then normalized against a U.S. armored division. The resulting value is called an armored division equivalent (ADE). All NATO and Warsaw Pact combat units can then, theoretically, be rated on a common basis using their ADE score. (Table 3 shows a simplified example of such a calculation.)

The Army established specific values of the WEIs for various NATO and Warsaw Pact weapons by assessing each weapon's capability. The weighting values, or WUVs, were also determined by the Army by pooling the opinions of military experts. The WEIs and WUVs used in this study were taken from a 1979 Army report that evaluated U.S. and foreign combat units and weapons that were expected to be fielded by 1986.2/ The report includes scores for almost

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2. Department of the Army, U.S. Army Concepts Analysis Agency, *Weapon Effectiveness Indices/Weighted Unit Values III (WEI/WUV III)* (November 1979).

TABLE 3. SAMPLE WEI/WUV CALCULATION OF A COMBAT DIVISION

Type of Weapon	Number in Unit	Weapon Effectiveness Index (WEI)	Product (Number x WEI)	Weighted Unit Value (WUV)	Total Score (Total product x WUV)
Tanks					
M60A3	150	1.11	166		
M1	150	1.31	197		
Total			363	94	34,122
Attack Helicopters					
AH-1S	21	1.00	21		
AH-64	18	1.77	32		
Total			53	109	5,777
Air Defense Weapons					
Vulcan	24	1.00	24	56	1,344
Infantry Fighting Vehicles					
Bradley fighting vehicle	228	1.00	228	71	16,188
Antitank Weapons					
TOW missile launcher	150	0.79	119		
Dragon launcher	240	0.69	166		
LAW	300	0.20	60		
Total			344	73	25,112
Artillery					
155mm howitzer	72	1.02	73		
8-inch howitzer	12	0.98	12		
MLRS	9	1.16	10		
Total			96	99	9,504
Mortars					
81mm	45	0.97	44		
107mm	50	1.00	50		
Total			94	55	5,170
Armored Personnel Carriers					
M113	500	1.00	500	30	15,000
Small Arms					
M16 rifle	2,000	1.00	2,000		
Machine guns	295	1.77	522		
Total			2,522	4	10,088
Division Total					122,305

The division's score in terms of ADEs = division score/norm for U.S. armored division. For this example, the division score = 122,305. When it is divided by the norm for a U.S. armored division--130,458--it is converted into ADEs. In this case, the illustrative division would be worth 0.94 ADEs.

SOURCE: Compiled by Congressional Budget Office from data in Department of the Army, U.S. Army Concepts Analysis Agency, *Weapon Effectiveness Indices/Weighted Unit Values III (WEI/WUV III)* (November 1979).

NOTES: TOW = tube-launched, optically tracked, wire-guided; LAW = light antitank weapon; MLRS = multiple launch rocket system; ADE = armored division equivalent.

all existing NATO and Warsaw Pact weapons and for those weapons likely to be fielded in significant numbers between now and 1993.

These are the latest data that are publicly available. More recent assessments performed by the Department of Defense either have used different methods or have been classified. However, the method for calculating individual WEIs is also explained in the 1979 study. Thus, CBO was able to determine effectiveness indices for those few weapons not evaluated by the Army in its 1979 report.

Limitations of this Method

Like any analysis that attempts to quantify the many aspects that contribute to military capability, the WEI/WUV approach suffers from several important drawbacks. One obvious drawback is the lack of more recent WEIs for the individual weapons currently in NATO and Warsaw Pact units. This analysis, however, does not purport to be a precise evaluation of either NATO's or the Warsaw Pact's military capability. Rather, it is an attempt to assess the relative position of the two sides under a wide range of assumptions. As such, it should be viewed as representing general trends and not absolute military capability; nor should the analysis be used to predict the outcome of a conflict. Thus, if the underlying numbers used to make the assessments err by a small percentage for each side, the relative error should cancel out. Even if this is not the case--that is, if the numbers provided by the 1979 study and updated by CBO result in a bias in either NATO's or the Pact's favor--such a bias would be relatively small. Given the wide range of cases examined, the errors resulting from using somewhat outdated information should be insignificant.

This analytic method also ignores many attributes of a military unit--such as quality and training of personnel, support equipment, logistic capability, and the interplay of various weapons--that can determine the outcome of a particular battle. Despite their importance, however, these factors often do not lend themselves to easy translation into numerical values. How do you count an American reserve soldier who received annual training versus a Soviet reservist who does not train after an initial term of enlistment? Is an American reservist worth 2.0 Soviet reservists or 1.5? Does a tank driven by an

American reservist count as more than one Soviet tank also driven by a reservist? Such comparisons are obviously subjective and not as amenable to quantification as tank range, accuracy, or speed. This is the case, too, with resupply and maintenance capability. Everyone knows that efficient ammunition and fuel resupply is necessary for the effective operation of a combat unit, but very few analysts have suggested ways to quantify such a capability. This shortcoming may be especially important because NATO devotes more of its resources to providing logistical support than does the Pact. NATO units do not receive credit for this effort in the WEI/WUV analysis, however. (See Appendix B for more detail on this point.)

Static comparisons like those using the WEI/WUV method also ignore other decisive variables, such as strategy, maneuver, terrain, and combat attrition, that determine the conduct of war. Indeed, the WEI/WUV method is useful primarily for evaluating the forces that each side could have at its disposal before the onset of hostilities, or the total forces that each side had mustered at a point after mobilization. Such comparisons, therefore, are more valuable for assessing the relative standing of opposing forces before a war starts, and are more useful for evaluating deterrence capability rather than war-fighting ability.

Finally, the WEI/WUV method assumes that the added benefit of additional weapons is linear--that is, more weapons of any kind continue to provide the same additional capability as the first such weapon. This assumption is called "constant marginal utility" in economic jargon and ignores the fact that, beyond a certain point, additional weapons of one kind might be redundant and therefore of no added utility. For this reason, WEI/WUV scores should not be used by themselves to determine the optimal mix of weapons in a division. Indeed, if this method were followed to its ultimate conclusion, a division would contain only those weapons that yielded the highest score for the least cost. Rather, the scores should be used to suggest how one mix of weapons deemed plausible by military experts might perform against another plausible mix.

Together these various limitations suggest that assessments of the conventional balance using WEI/WUV scores cannot predict the outcome of a confrontation between NATO and the Warsaw Pact.

WEI/WUV scores are, however, useful tools in investigating the effects of various assumptions on today's conventional balance.

THE BALANCE OF GROUND FORCES IN THE CENTRAL REGION

The balance of NATO and Warsaw Pact forces in the central region of Europe depends on the quantity and quality of each side's weapons, the amount of time needed to make the forces bearing those weapons available in the central region, and exactly which forces should be counted. Each of these factors introduces uncertainty that is important in assessing the balance.

Quantity and Quality of Weapons

The forces summarized in Table 2 include those available throughout the entire European theater, from Norway to Turkey. The debate concerning the Warsaw Pact/NATO balance typically focuses on the central region, which is confined to the inter-German border. Soviet doctrine calls for a quick victory in this area before the West's economic strength and manpower advantage can be fully mobilized.[3] In this region, the Pact could have an advantage in divisions of 121 to 72.[4] (See Appendix C for a detailed list of the forces included in this tally.)

When all divisions are converted to armored division equivalents (ADEs) using the WEI/WUV method, the ratio is reduced. When rated against a U.S. armored division, for example, a Soviet tank or motorized rifle division has about 60 percent to 70 percent of the U.S. armored division's capability, depending on the type of division and its state of readiness in peacetime. Thus, the Warsaw Pact's total of 121 divisions available to the central European theater would be equal to only 75 ADEs, and NATO's 72 divisions--a collection of many types of divisions from many nations--would be reduced to about 49 ADEs. Converting the two sides' combat divisions to ADEs therefore reduces the ratio from roughly 1.7 to 1.0 (121 to 72 divisions) to just about 1.5 to 1.0. This reduction in the Warsaw Pact's advantage stems primarily from the larger size of NATO's divisions and the generally superior quality of NATO's weapons.

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[3] Christopher Redman, "Battle of the Bean Counters," *Time* (June 15, 1987), p. 33.

[4] This region includes Pact divisions from East Germany, Poland, and Czechoslovakia, the Soviet divisions stationed in those countries, and those of the Soviet Union's western and central military districts.

Availability of Forces

To prevail in war, one must not only have high-quality weapons, but these weapons must be available when needed. Neither all of the Pact's 121 divisions nor all of NATO's 72 divisions are currently in place in the central European region. Each side would require a considerable period of time to aggregate such a large force near the East-West German border. In fact, only 42 of NATO's 72 divisions available for the central region are actually situated in or near West Germany. Similarly, only 40 of the Pact's 121 divisions are currently stationed in either East Germany or Czechoslovakia, the two Warsaw Pact countries that border on West Germany. All other divisions for both NATO and the Warsaw Pact are stationed out of the region and would have to be transported to the area in times of increasing tension. Twenty-five of NATO's divisions would have to be transferred from the continental United States. The same holds true for 64 Soviet divisions that would have to be transferred from their home districts in the Soviet Union to the European theater.

Questions arise concerning the readiness and availability of units that are not on active duty at the outbreak of hostilities. Most of NATO's 72 divisions are on active duty during peacetime; in fact, only 20 of the 72 divisions would be formed from reserve units, which usually train just a few days a month. In contrast, only 52 of the 121 Warsaw Pact divisions would be considered totally combat-ready during peacetime. Although all Warsaw Pact divisions are referred to as "active," they are maintained at various levels of readiness and have been labeled as Category I, II, or III based on the status of their personnel and equipment.5/ Category I divisions are maintained at full strength with a full set of modern equipment; Category II divisions are typically manned at 50 percent to 75 percent strength and have their full complement of fighting vehicles; Category III divi-

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5. Definition of categories is from International Institute for Strategic Studies, *The Military Balance, 1987-1988*, p. 34.

sions are maintained at cadre strength (about 20 percent), and while they might have a full set of combat equipment, that set would typically include older models. Of the 69 Pact divisions that are not combat-ready, about 20 would be Category II and the rest Category III. Those spaces in Category II and III divisions that are not filled by people on active duty would have to be filled after mobilization began, either by new recruits who would need training or by reserve personnel. (Soviet reserves have had two years of military training but do not generally have any refresher training following their initial military service.)

Unfortunately, unclassified literature contains little information on how long it might take the Warsaw Pact nations to prepare these less ready divisions for combat. Furthermore, most of the divisions that would have to travel long distances to reach the inter-German border would be Category II or III units (see Figure 2). Estimates of the time needed to ready all of these divisions for combat and to bring them from western and central Russia to the battlefront vary from just over two weeks to as long as four months.6/ Uncertainty also surrounds estimates of the time needed by the United States to ready its reserve divisions and transport them to Europe, even though official estimates put the delay at 11 weeks.7/

Questions and doubts also exist as to the speediness with which NATO would detect and respond to a Warsaw Pact provocation. The shortest delay, of course, would be none, implying that NATO immediately detects the beginning of Warsaw Pact mobilization and decides to initiate its own. Longer delays are certainly possible, however, either because of difficulty in recognizing the beginning of Pact mobilization or because of political indecision within NATO. It seems plausible that delays of a week or more could occur between the beginning of Pact mobilization and the start of NATO mobilization.

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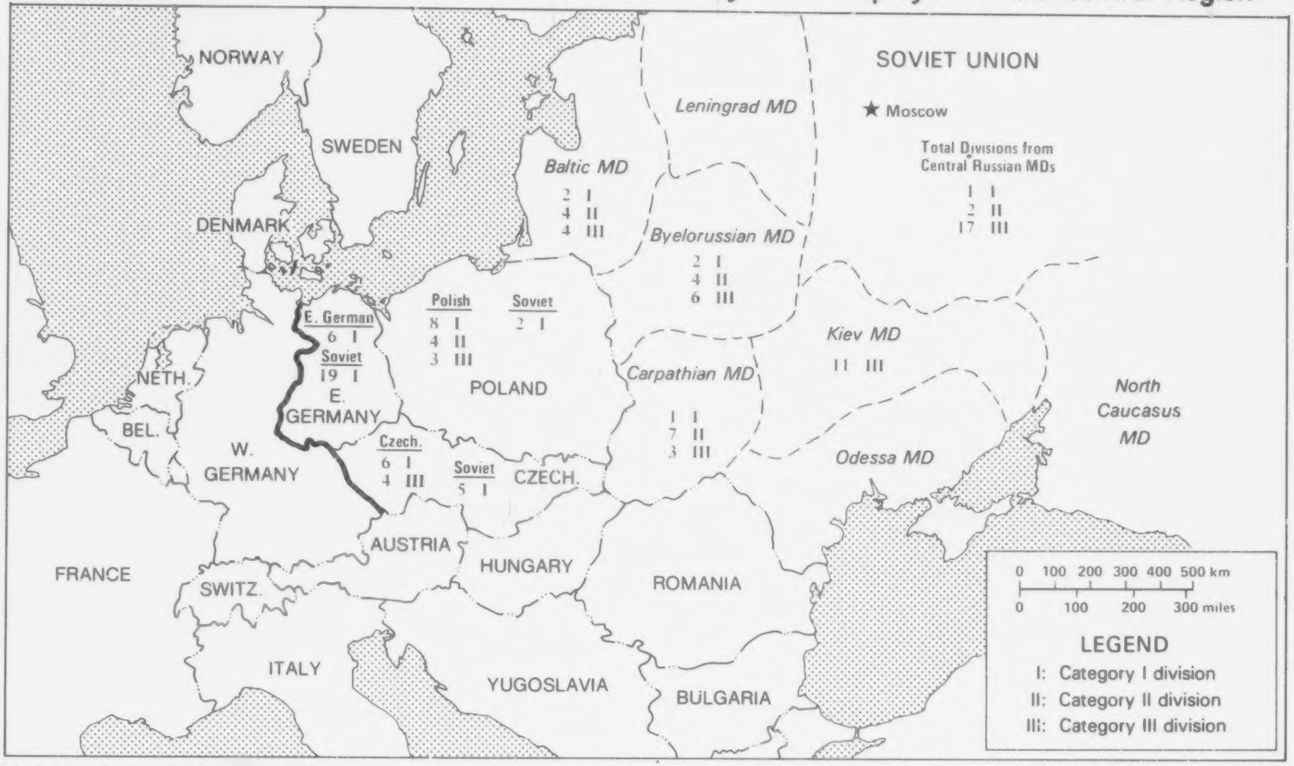
6. Because some Soviet divisions have very few active-duty personnel, making them ready for combat could take much longer--perhaps many months rather than only a few.

7. Department of Defense, Office of the Assistant Secretary of Defense for Program Analysis and Evaluation, *NATO Center Region Military Balance Study, 1978-1984* (July 1979), Annex A.

Figure 2.

Peacetime Locations of Warsaw Pact Divisions Likely to Be Deployed to the Central Region


NORWAY
SWEDEN
DENMARK
NETH.
BEL.
FRANCE
W. GERMANY
E. GERMANY
E. German
6 I
Soviet
19 I
SWITZ.
ITALY
AUSTRIA
Czech.
6 I
4 III
Soviet
5 I
CZECH.
Polish
8 I
4 II
3 III
Soviet
2 I
POLAND
HUNGARY
YUGOSLAVIA
ROMANIA
BULGARIA
Baltic MD
2 I
4 II
4 III
Leningrad MD
Byelorussian MD
2 I
4 II
6 III
Carpathian MD
1 I
7 II
3 III
Kiev MD
11 III
Odessa MD
North Caucasus MD
SOVIET UNION
Moscow
Total Divisions from Central Russian MDs
1 I
2 II
17 III
0 100 200 300 400 500 km
0 100 200 300 miles
LEGEND
I: Category I division
II: Category II division
III: Category III division

SOURCE: Congressional Budget Office based on information in International Institute for Strategic Studies, *The Military Balance, 1987-1988* (London: IISS, 1987); and in William P. Mako, *U.S. Ground Forces and the Defense of Central Europe* (Washington, D.C.: Brookings Institution, 1983).

NOTES: Category I divisions are at full strength with a full set of modern equipment. Category II divisions are typically at 50 percent to 75 percent strength with a full complement of fighting vehicles. Category III divisions are at 20 percent strength, might have a full set of combat equipment, but it would typically include older models.

MD = Military District.

Allied Participation

The final consideration that affects the number of forces available to each side is the role that various allies might play. In general, the NATO countries are considered to be more reliable allies than are the Warsaw Pact countries. Even France, though not a military member of NATO, is considered likely to contribute forces to the defense of western Europe. The French army currently includes 15 divisions, which could be available to defend the central region seven days after mobilization. These divisions represent about 20 percent of NATO's total ground forces. (France's 15 divisions account for only 8 percent of NATO's combat capability when measured in ADEs.) France's contribution cannot be taken for granted, however, since it is not bound by treaty to participate in NATO military activities.

Nor can the Soviet Union be extremely confident of the participation of its allies. Poland and Czechoslovakia, even though they have signed the Warsaw Pact, might not be willing to participate in an invasion of western Europe. Indeed, even if the political leadership of those countries should decide to follow the Soviet lead, it is not clear that such a decision would have the support of the enlisted forces or the general populace of either country.

A further asymmetry exists between NATO and the Warsaw Pact with respect to their allies. France's nonparticipation with the rest of NATO would, in theory, not hinder NATO's efforts. Based on current plans, NATO reinforcements would not need to traverse France, nor would NATO need to establish staging or air bases in France. On the other hand, France's participation and the availability of French ports and transportation networks could greatly enhance NATO's flexibility, should German ports or staging areas be lost.

In contrast, a Pact invasion of western Europe requires that Soviet reinforcements and supplies traverse Poland. If Polish units do not assist the Soviet forces by protecting these transit routes and helping to secure staging bases, some Soviet troops might need to be diverted to perform this mission. As a result, the Pact might lose the combat capability not only of its allied Polish units but also of the diverted Soviet troops.

Results Under Various Assumptions

The balance assessment in this study results from the use of the WEI/WUV method to calculate ADEs available to the Pact in the central region at each day after the Pact decides to mobilize; ADEs available to NATO forces on the same day are determined the same way. Thus, the results reflect both the quantity and quality of weapons available to each side and how quickly they arrive in the central region. Results are expressed as a ratio of Pact ADEs to those for NATO. A ratio exceeding 1.0 favors the Pact and vice versa.

No one can predict with certainty how long it will take the Pact forces to mobilize, what role the various allies will play, or how long NATO will take to mobilize after the Pact begins to do so. Therefore, rather than to assume arbitrarily one set of analytic conditions, it is more appropriate to examine the Pact/NATO ground force balance under varying conditions.

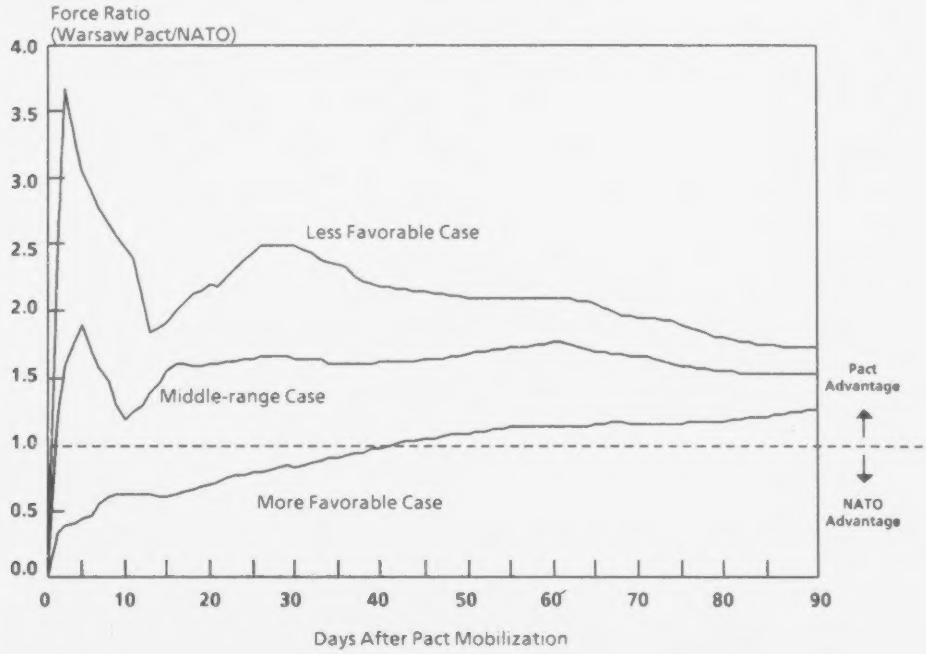
Case 1: More Favorable to NATO. A case that would be favorable to NATO would be one in which the Soviet Union's allies--Poland and Czechoslovakia--chose not to participate in a Soviet-led Warsaw Pact invasion and in which France contributed forces to NATO. (Although Soviet combat troops might have to be diverted to perform tasks that would otherwise be performed by Polish forces, this added disadvantage to the Pact is not taken into account here.) This case also assumes that NATO immediately detects a Pact mobilization and begins one of its own, and that the Pact mobilization schedule requires a long period--90 days--for the last of the Soviet divisions from the central military districts to reach the theater of operations.

The assumptions of this case yield analytic results suggesting that the Soviet Union and its Warsaw Pact allies might not achieve an advantageous position within 90 days of mobilization (see Figure 3). For the first 40 days after the Pact begins to mobilize, the ratio of available ADEs would be less than 1.0, suggesting inferior Pact capability and a NATO advantage. If the WEI/WUV analysis correctly represents the relative positions of the Warsaw Pact and NATO, then--under these circumstances--the Warsaw Pact might never attack, which would ensure deterrence.

Case 2: Less Favorable to NATO. Assumptions leading to the other extreme, the "less favorable case" for NATO, result in a situation that clearly favors the Warsaw Pact. This case assumes that the Soviet allies participate and France does not, that Soviet divisions from the central districts of the Soviet Union reach the front within 25 days after mobilization, and that it takes NATO seven days to detect the Pact's mobilization and to begin its own preparations for war.

Ratios of available forces that result from this set of assumptions are very different from those obtained previously, with the Pact achieving an advantage of 3.7 to 1.0 in the first few days after mobilization and a consistent advantage of greater than 1.7 to 1.0 (see Figure 3). Evidence of such an advantage, though not ensuring a

Figure 3.
Force Ratios in the European Central Region



SOURCE: Congressional Budget Office based on Department of Defense data and on William P. Mako, *U.S. Ground Forces and the Defense of Central Europe* (Washington, D.C.: Brookings Institution, 1983).

Warsaw Pact victory, could persuade the Pact that it could greatly outnumber and possibly overwhelm opposing NATO conventional forces, leaving NATO to rely on nuclear forces for deterrence.

Case 3: Middle Range of Assumptions. A final, middle-range scenario is based on the assumption that all allies from both sides participate, that the time to prepare the last of the Pact's less ready divisions and transport them to the front would be roughly two months, and that NATO would detect and would begin to prepare for war within four days after the Pact mobilizes. This set of assumptions produces ratios of ADEs in the central region that peak at about 1.9 on the fourth day after the Pact forces start to mobilize, drop to about 1.2 after nine days when all of NATO's divisions in the central region during peacetime are ready for combat, and then stabilize at a value of 1.6 or slightly higher for the next 75 days (see Figure 3). Thus, the ratios established by the WEI/WUV method in this middle-range case would also indicate that the Pact might have a numerical advantage in the central region, though not as overwhelming an edge as in the previous case.

What the Ratios Mean

But how much of an advantage would the Warsaw Pact need to be confident of victory? Are the ratios in the case of the middle-range assumptions (generally between 1.2 and 1.7) adequate? Or would confidence come only from higher ratios such as those in the case that is more favorable to the Warsaw Pact? Opinions differ widely.

In all these assessments, Warsaw Pact forces are assumed to be on the attack, attempting to push into NATO territory. Attackers have some advantages; for example, they can choose the point of attack and mass their forces there. But defenders also have advantages; they can assume protected positions on the periphery of the attacker's route and attempt to destroy attacking forces. Historical evidence and general military doctrine hold that, because of the defender's advantages, the attacker must achieve a force ratio of at least 3 to 1 at the point of attack in order to have confidence of success. Soviet defense literature suggests that they would try to achieve an advantage of at least 4 or 5 to 1 on their main axes of attack.

What theaterwide force ratio would allow an attacker to achieve a ratio of 3 to 1 or better at a point of attack while also attacking in smaller numbers elsewhere in order to pin down other NATO forces? The answer depends on how quickly each side could move its forces and on the strategies employed by both the attacker and the defender. As a result, many values have been suggested by defense analysts as necessary to achieve the needed local force ratios. Recent studies have concluded that if NATO can limit the Pact's theaterwide advantage to between 1.2 and 2.0, a Warsaw Pact invasion could be thwarted.8/

This wide range of ratios, and of opinions about what ratio would provide confidence of victory, illustrates the uncertainty that faces any military planner, particularly the Soviet leaders. They cannot know ahead of time how their allies will react to a call to mobilize or how quickly NATO will respond. The theaterwide ratios determined here suggest that neither side can predict the outcome of any confrontation with certainty: the Warsaw Pact could not be confident of an easy victory, nor could NATO be sure of a steadfast defense.

Contribution of Tactical Air Forces

The relative standing of each side may also be affected by the impact of their tactical air forces, which was not considered in the ratios just discussed. Tactical air forces affect the conduct of the ground war by destroying equipment or the roads and bridges needed to move equipment. These forces consist of various types of aircraft with differing missions. Fighters and interceptors are designed to attack and destroy enemy aircraft and, by doing so, gain control of the skies. Fighter-bombers, also referred to as ground-attack aircraft, are designed to attack enemy equipment on the ground as well as targets like roads, bridges, and radar installations.

Most tallies of all the Warsaw Pact and NATO tactical aircraft throughout Europe give a significant advantage to the Pact. (The

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8. John J. Mearsheimer, *Conventional Deterrence* (London: Cornell University Press, 1983), p. 174; Congressional Budget Office, *U.S. Ground Forces: Design and Cost Alternatives for NATO and Non-NATO Contingencies* (December 1980), p. 18; and Congressional Budget Office, *Army Ground Combat Modernization for the 1980s: Potential Costs and Effects for NATO* (November 1982), p. xiv.

TABLE 4. NATO AND WARSAW PACT TACTICAL AIRCRAFT IN THE CENTRAL REGION

	Before Mobilization			Ten Days After Mobilization		
	Fighters	Fighter-Bombers	Total	Fighters	Fighter-Bombers	Total
NATO	586	1,498	2,084	802	2,797	3,599
Pact	1,665 a/	1,204	2,869	2,015 b/	1,249	3,264

SOURCE: Compiled by the Congressional Budget Office based on data from International Institute for Strategic Studies, *The Military Balance, 1987-1988* (London: IISS, 1987); and The Analytic Sciences Corporation, "Preliminary Atlantic-to-the-Urals Unclassified Conventional Weapon Systems Data Base," Personal communication, Fall 1987.

a. Includes 535 interceptors best suited for air defense.

b. Includes 795 interceptors.

estimates presented in Table 2, for example, yield a Pact/NATO ratio of 1.3 to 1.0.) Within the central region alone, however, the opposing tactical air forces appear more even. (See Table 4 and Appendix C for a more detailed listing of NATO and Warsaw Pact aircraft.) Furthermore, the composition of the Pact's air forces differs significantly from NATO's in that they include many more fighters that are interceptors designed specifically for defending the home country. Indeed, a comparison of the two sides' fighter-bomber aircraft--those most likely to influence the ground battle--within the central region shows NATO with a distinct advantage. Furthermore, most analysts credit NATO with pilots that are better trained, and aircraft and weapons that are more sophisticated, than their Pact counterparts.

Just as the WEI/WUV method attempts to reduce ground forces of differing quality to a common denominator, a similar method devised by The Analytical Sciences Corporation compares tactical aircraft.[9] The TASCFORM model, as the method is called, attempts to account for the superior sophistication and capability of NATO aircraft.

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[9] The Analytical Sciences Corporation, *The TASCFORM Methodology: A Technique for Assessing Comparative Force Modernization* (Arlington, Va.: TASC, January 1984).

Based on a simple numerical comparison, NATO aircraft outnumber Warsaw Pact aircraft in the central region by a ratio of 1.1 to 1.0 ten days after mobilization. When the relative effectiveness of each type of aircraft is taken into account using the TASCFORM model, however, the ratio increases to 1.5 to 1.0. If the Pact's interceptor aircraft are discounted because they are likely to be held back to defend home areas, the ratio increases further to 1.9 to 1.0. If the fighter-bomber category is considered alone, the ratio is even more decidedly in NATO's favor.

Thus, NATO's ground-attack aircraft may partially offset the Pact's advantage in ground forces. William Kaufmann equated the contribution of NATO's tactical aircraft to that of two and two-thirds armored division equivalents.10/ Adding two and two-thirds ADEs to NATO's total forces could result in about a 5 percent reduction in the Pact/NATO force ratio. Other studies have attributed even larger contributions to tactical aircraft.11/

BALANCE IN CORPS SECTORS

It may not be sufficient to consider only the theaterwide or overall balance of forces within the central region. The Pact almost certainly would concentrate its forces in a few sections of the central region in hopes of penetrating NATO's lines. Once the Pact had broken through NATO defenses, NATO forces would face the difficult task of defending their rear areas as well as contending with attacks from

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10. William W. Kaufmann, "Nonnuclear Deterrence," in John D. Steinbruner and Leon V. Sigal, eds., *Alliance Security* (Washington, D.C.: Brookings Institution, 1983), pp. 76 and 77.

11. In his analysis of the conventional balance in Europe, Barry Posen claims that NATO's tactical aircraft could help redress the generally unfavorable ground force ratio. He argues that in five weeks of combat, through superior weaponry and aircraft reliability, NATO ground-attack aircraft could destroy nine Pact ADEs. During the same period, he argues, Pact aircraft could destroy only four NATO ADEs, resulting in a net gain in NATO's favor of five ADEs. See Barry R. Posen, "Measuring the European Conventional Balance," *International Security*, vol. 9 (Winter 1984-1985), p. 73.

    A study by the Office of the Secretary of Defense (OSD) conducted in 1979 also concluded that NATO's superior ground-attack aircraft could destroy up to 23,000 armored fighting vehicles, the equivalent of 17 ADEs, during a 30-day campaign. The study concluded that, with such a capability, "NATO's tactical air forces could significantly enhance the ground force's ability to contain a Warsaw Pact attack." (See Department of Defense, *NATO Center Region Military Balance Study, 1978-1984*, pp. II-32 and II-34.)

their front. Thus, it is important to consider not only the theaterwide balance but also the balance within each section. Individual sections, which are called corps, are designated by the name of the country defending that area and by a Roman numeral--for example, U.S. V Corps or British I Corps (see Figure 4).

An assessment of each corps is particularly important because the capabilities of the forces defending the corps vary widely. For example, in the U.S. V Corps, each of the four U.S. divisions defending the sector will soon have the advanced M1A1 tank and Bradley fighting vehicle, both regarded as superior to similar equipment in the Warsaw Pact forces. The British I Corps, however, though equipped with the Chieftain tank and the Ferret armored fighting vehicle (judged to be of about the same capability as the Soviet T-80 tank and BMP fighting vehicle, respectively) would only be defended by three divisions, each with less than half the number of tanks and fighting vehicles of corresponding U.S. armored divisions.

How great is this corp-to-corps disparity? As an illustration, CBO examined the force ratios in two corps--one from the northern area of the central region called NORTHAG and one from the central area, or CENTAG, discussed above. For the purposes of the numerical analysis, a specific corps was chosen from each section to serve as examples--the U.S. V Corps from CENTAG and the British I Corps from NORTHAG.12/ The overall assumptions in this analysis are the same as those in the middle-range case.

Assessing the balance of forces in each corps requires not only an assumption about total Warsaw Pact forces that could attack but also assumptions about *where* they attack. The assumptions in this analysis are arbitrary but plausible. The study assumes that Warsaw Pact forces make two attacks in NORTHAG and one in CENTAG (see Figure 4 and Table 5). Such a strategy seems plausible for several reasons. It would enable the Pact to mass its armored forces in the northern German plain--an area that has long been considered

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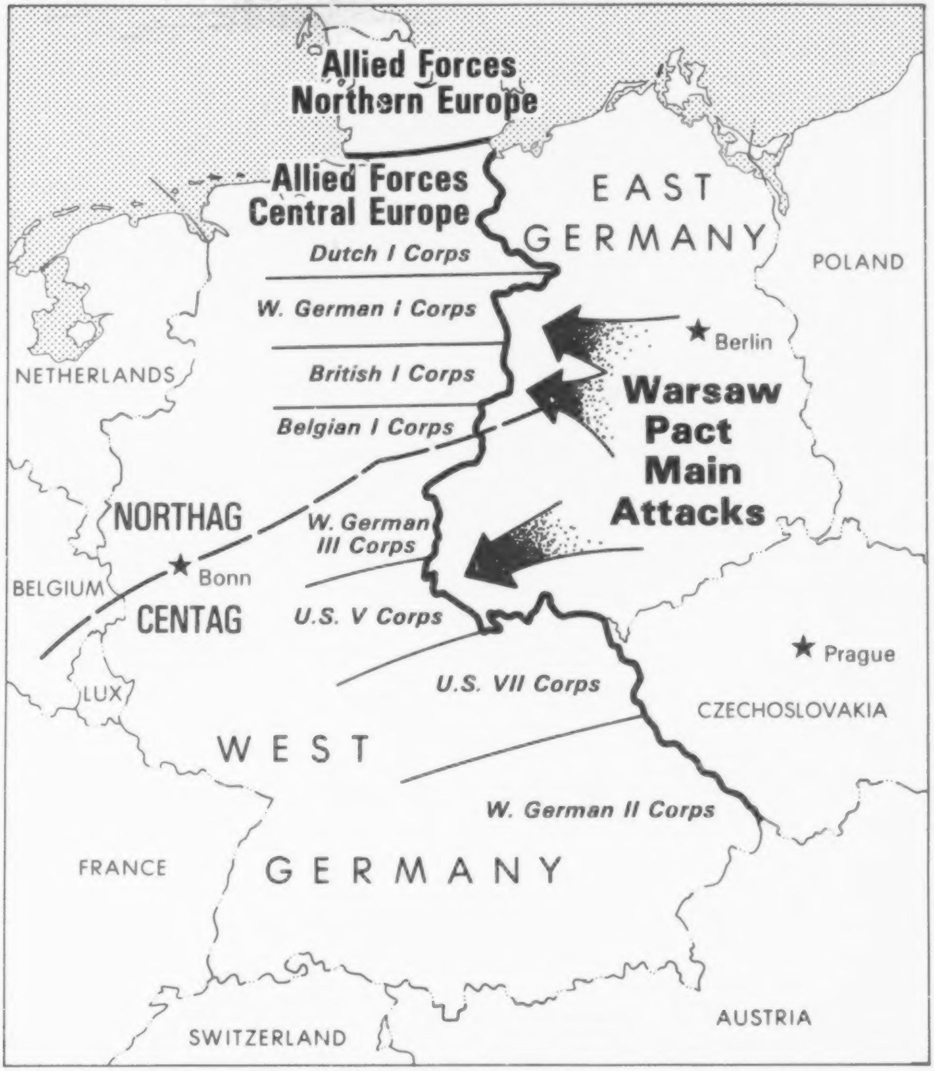
12. The West German I Corps could also have served as a representative NORTHAG corps, since its capability is roughly equivalent to that of the British corps, and it is also opposite a main corridor of attack by Pact forces.

Figure 4.
Specific Corps Designations and Assumed Corridors of Pact Invasion


Allied Forces
Northern Europe
Allied Forces
Central Europe
EAST
GERMANY
POLAND
Dutch I Corps
W. German I Corps
Berlin
British I Corps
NETHERLANDS
Belgian I Corps
Warsaw
Pact
Main
Attacks
NORTHAG
W. German
III Corps
Bonn
BELGIUM
CENTAG
U.S. V Corps
Prague
U.S. VII Corps
CZECHOSLOVAKIA
LUX
WEST
W. German II Corps
FRANCE
GERMANY
AUSTRIA
SWITZERLAND

SOURCE: Adapted by Congressional Budget Office from Richard Lawrence and Jeffrey Record, *U.S. Force Structure in NATO* (Washington, D.C.: Brookings Institution, 1974), p. 31, and also from U.S. Army material.

NOTE: NORTHAG (Northern Army Group) and CENTAG (Central Army Group) are the two subdivisions of NATO forces in West Germany. The line dividing the two runs from Belgium through West Germany, just south of Bonn, and into East Germany.

TABLE 5. NUMBER OF ATTACKING WARSAW PACT ARMORED DIVISION EQUIVALENTS ASSUMED IN CORPS-TO-CORPS ANALYSIS

NATO Corps	Days After Soviet Mobilization 15	30	45	60
British I (or West German I)	15	17	19	21
U.S. V	9	11	13	15
All Other a/	3	3	3	3

SOURCE: Compiled by Congressional Budget Office based on Department of Defense data.

NOTE: Based on the distribution in Department of Defense, Office of the Assistant Secretary of Defense for Program Analysis and Evaluation, *NATO Center Region Military Balance Study, 1978-1984* (July 1979), until 15 days after mobilization. After that, one-third of the Pact reinforcing units is distributed to each of the three corps facing a main attack.

a. Per each of the five remaining corps facing only secondary attacks.

relatively favorable for tank warfare.13/ Furthermore, it would put a greater strain on NATO's NORTHAG, which has a smaller backup force than neighboring CENTAG. Finally, many defense analysts consider the NORTHAG corps to be more likely targets for the main Pact assaults because their defenses are less well equipped than those in CENTAG.14/

The ratios of armored division equivalents in the two corps differ markedly (see Figure 5). Whereas, except for the fourth day after mobilization, ratios of Pact to NATO forces in the U.S. V Corps never exceed 1.5 to 1.0, those in the NORTHAG corps are, at some points, more than twice as high. Indeed, based on the assumptions used here, the force ratio exceeds 3 to 1 shortly after the Pact starts to mobilize. If this analysis, despite its shortcomings, actually reflects the likely

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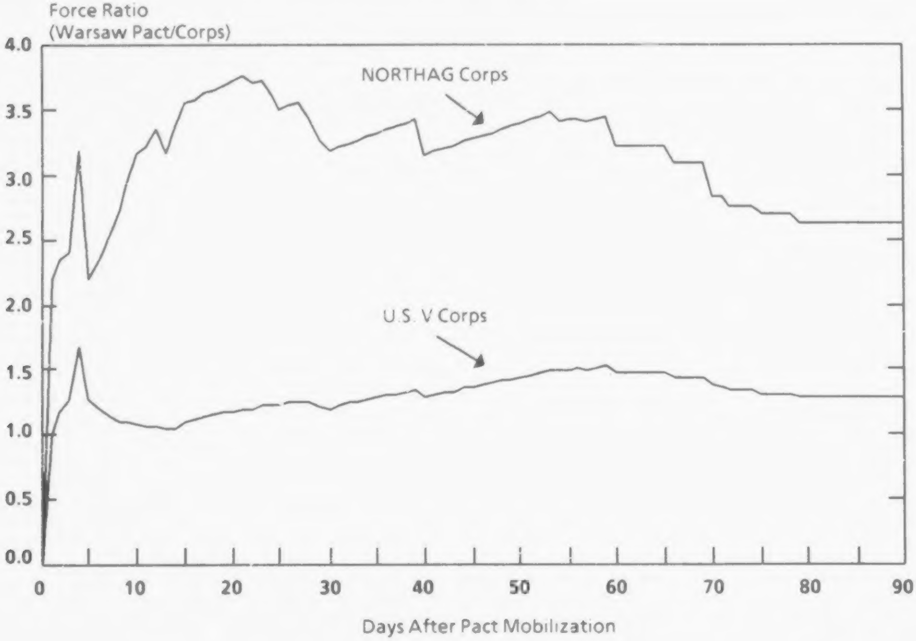
13. Although the northern German plain is better suited to armored operations than central Germany, attacking that region would not necessarily be easy. The region has numerous bogs and sinkholes and is cut north to south by several major rivers. Furthermore, much of northern Germany is being built up. Developed regions with densely packed buildings are formidable obstacles for any attacker.

14. John Barry and Russell Watson, "Can Europe Stand on Its Own Feet?" *Newsweek* (December 7, 1987), p. 31.

deployment of forces in a NORTHAG corps, the possibility of such a lopsided advantage could be seen as an encouragement, rather than as a deterrent, to a Pact attack.

As mentioned earlier in this chapter, static methods for analyzing force balances do not take many factors into account, combat losses being perhaps the most important. Dynamic methods, however, attempt to capture the effects of combat losses and, to some extent, support from tactical aircraft. Since combat conditions across a theater almost 800 kilometers wide would vary greatly, dynamic analyses are most useful when applied to the progress of combat in a particular corps sector.

Figure 5.
Illustrative Force Ratios in Two NATO Corps



SOURCE: Congressional Budget Office based on Department of Defense data.

To achieve a clearer understanding of the balance within a specific corps, this study supplemented static measures with the results from a simple dynamic model developed by Joshua Epstein of the Brookings Institution.15/ The model can be used to measure the combat capability and territory lost by NATO during a Warsaw Pact attack and attempts to simulate both ground combat and the contribution of each side's tactical aircraft to the ground war. (Appendix A discusses this model more fully and includes important critiques of this and other dynamic modeling techniques.)

Figures 6 and 7 reflect the results of the model's simulation of a Warsaw Pact attack with main corridors opposite the U.S. V Corps and two NORTHAG corps. The distribution of forces is the same as that assumed in generating the static force ratios shown in Figure 5. After actual hostilities commence (assumed here to be 15 days after the Pact starts to mobilize), however, the impact of combat losses is obvious. In particular, the assumed heavy combat losses in the NORTHAG corps cause the Warsaw Pact/corps force ratio to worsen progressively. Based on the dynamic analysis, the U.S. V Corps would be able to hold its own, again corroborating what would be expected based on the force ratios determined by the static method.

This particular dynamic model also simulates the amount of territory ceded by the defending forces as they attempt to limit their combat losses. As shown in Figure 7, much more territory would be abandoned by the hard-pressed NORTHAG corps than by the U.S. corps, which, based on the assumptions and methods associated with the model, is capable of fending off the attack.

The results of the dynamic model, as applied to individual corps sectors, should not be used to predict the outcome of a battle in those areas. Rather, they are intended as an illustration of the different types of results that can be obtained with dynamic versus static analyses. Neither method accurately reflects the actual capability of either side to conduct war, nor can either method predict the likely victor in the event of hostilities. There are too many intangibles, such as troop training and morale, leadership, and tactics, that cannot be captured by either method.

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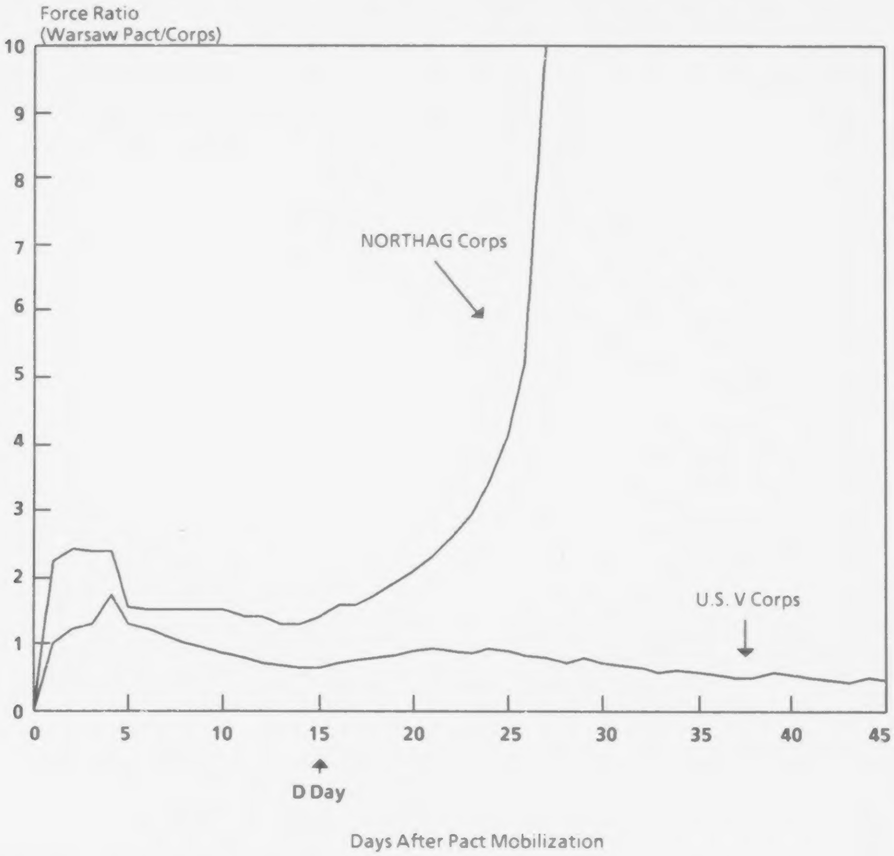
15. Joshua M. Epstein, *The Calculus of Conventional War: Dynamic Analysis Without Lanchester Theory* (Washington, D.C.: Brookings Institution, 1985).

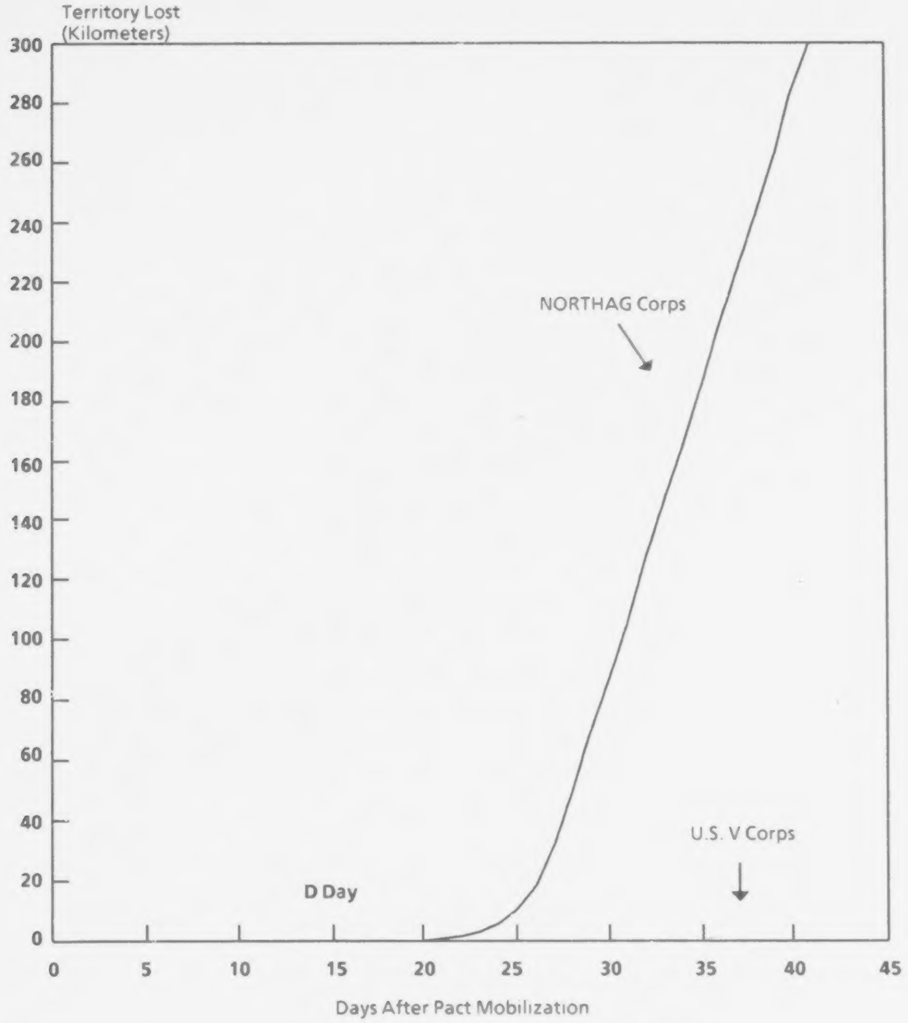
Models can, however, be used to highlight trends. In this case, it is analytically reassuring that both the dynamic and the static methods demonstrate the disparity in capability between the U.S. V Corps and a corps in NORTHAG. Because the specific force ratios

Figure 6.
Force Ratios in Two NATO Corps Based on Dynamic Analysis



SOURCE: Congressional Budget Office based on Department of Defense data.

Figure 7.
Simulation of Territory Lost in Two NATO Corps



SOURCE: Congressional Budget Office based on Department of Defense data.

NOTE: U.S. V Corps loses no territory in simulation.

within each corps are a function of both NATO's and the Warsaw Pact's deployment strategies, this analysis is not intended as a comment on the relative capability of a particular country's corps. It does suggest, however, that if the Pact could concentrate its forces in a few selected spots, NATO might not be able to deter an attack. Thus, even though the balance in the entire central region might not make the Warsaw Pact confident that their attack would be successful, the balance in certain sectors could be more encouraging.

CONCLUSION

The analysis presented here leads to the conclusion that neither side can be confident of an easy victory should conflict occur, a situation that may in itself provide effective deterrence. Although it may be possible to determine with some certainty the number of troops, tanks, and tactical aircraft that each side might have at its command, it is less certain when those assets will arrive in theater and how those soldiers and weapons will perform in combat. Quantifying the impact of tactical aircraft on the conduct of the ground war, the role and contribution of support and logistic forces, and the relative capability of the various NATO corps is even more difficult. Finally, it is impossible for either side to predict with certainty the behavior of its allies or its adversary in the event of a conflict. All these factors contribute to the uncertainty facing an attacker.

CHAPTER III

ALTERNATIVES FOR IMPROVING NATO'S CONVENTIONAL GROUND FORCES

As a result of its analysis of the relative military capability of the Warsaw Pact and NATO, discussed in the previous chapter, CBO concluded that neither side could be confident of victory should a military conflict occur in Europe. Despite this uncertainty, the side that initiated a conflict would benefit from several advantages. The attacker in a conventional war, assumed in this study to be the Warsaw Pact, picks the time and place to start the war and thus can plan on exploiting the opponent's specific weaknesses. Analysis in the previous chapter suggested that NATO would be more vulnerable if the Pact mobilized quickly and if the Pact concentrated some of its forces against particular NATO corps. This chapter examines various alternatives that the Congress might consider in an attempt to strengthen NATO and reduce its vulnerabilities.

The analysis in this chapter considers three approaches for improving NATO's conventional capability that could yield results within the next five years. The three strategies include adding barriers in the Federal Republic of Germany to delay a Warsaw Pact attack, acquiring more advanced weapons designed for close combat, and adding more divisions. The chapter also examines a fourth approach that would improve NATO's ability to attack the Warsaw Pact forces that would follow up the initial attack. This approach, in contrast to the other three, would not offer additional capability until the mid-1990s at the earliest. These four alternatives cover several major proposals now being discussed to improve conventional capability, but they are by no means the only options. For example, the alternatives do not include improving the training of NATO forces, providing NATO with more or better tactical aircraft, or improving NATO's support forces.

The improved capability under each of the four alternatives is compared with current NATO capability under the conditions of the middle-range case described in the previous chapter. The Warsaw Pact's capability has been upgraded to reflect improvements in its forces that are likely to be realized between now and 1993. The most significant improvements include increased numbers of the most modern Soviet tank (the T-80) and attack helicopters deployed with Pact forces. No new types of weapons are introduced into the Soviet forces because it is unlikely that any totally new weapon system would be widely deployed within the next five years.

The impact of each of the four alternatives on NATO's military standing relative to that of the Pact was measured using both the static method (the weapon effectiveness indices/weighted unit values method) and the dynamic model described in the previous chapter and in Appendix A. Since neither method was deemed totally satisfactory for assessing the benefit of all four alternatives, both were used in an attempt to compensate for the shortcomings of each. For instance, because the dynamic method is not well suited for making theaterwide assessments, the static method was used--even when not totally appropriate--to maintain a consistent basis for comparison throughout the study. On the other hand, the static method cannot easily or adequately capture the effects of the barriers examined in Alternative I or the follow-on forces attack (FOFA) approach discussed in the last alternative. The dynamic method should therefore be viewed as the more valid technique when considering the impact of those two alternatives. Since each method alone suffers from individual drawbacks, the strongest conclusions can be drawn when the same trend is evident from both the static and dynamic analyses.

Total costs of each alternative are also estimated. This study assumes that all costs are borne by the United States, since the Administration and the Congress can control only U.S. funds. If, however, the United States paid only a portion, then costs of these alternatives would be lower (perhaps by 48 percent if, for example, the United States paid a portion equal to its fraction of the gross national product of all the NATO nations).

ALTERNATIVE I: CONSTRUCT BARRIERS ALONG THE INTER-GERMAN BORDER

The Warsaw Pact, according to the force ratios calculated in the previous chapter, generally enjoys its largest advantage over NATO during the first few days following mobilization of its forces. After 7 to 12 days, however, the Pact's advantage would diminish as NATO reinforcements begin to arrive. Several analysts have suggested that barriers along the inter-German border could provide NATO with additional time to marshal reserves and greatly improve the alliance's ability to stop a Pact invasion.[1]

NATO already has plans for planting mine fields along the border before an invasion. But more could be done. Several schemes have been suggested for creating effective barriers to tanks along the border, such as digging concrete-lined ditches that would be difficult for tanks to cross. Suggestions for less obtrusive barriers include burying containers that would be left empty until just before an invasion when they would be filled with explosives and detonated to create ditches, or grading slopes to 40 degrees along the border and planting them with trees, creating a slope that is impassable to any existing tank.[2] An even more extensive barrier--up to 40 kilometers deep and consisting of forested areas, irrigation and recreation lakes, walled terraces, and prepared defensive positions--has also been proposed.[3]

Although these obstacles would not stop a Pact invasion, they could give NATO additional time to bring its forces up to full combat-readiness and get them into defensive positions before the first Pact forces could engage NATO units in direct combat. Slowing or temporarily halting a Pact advance would also allow NATO to realign its forces along the theater front, positioning them where they would be needed most. Furthermore, if the barriers could not easily be breached or destroyed by Pact artillery, they would create choke

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1. Frank Carlucci, as quoted by the *Washington Post* in "Carlucci Asks 'Creative' Response to NATO," December 1, 1987, p. 23; Robert Komer, "A Credible Conventional Option: Can NATO Afford It?" *Strategic Review* (Spring 1984), p. 35; Congressman Les Aspin, "The World After Zero INF" (speech presented to the American Association for the Advancement of Science Colloquium on Arms Control, Arlington, Va., September 29, 1987); Leon V. Sigal, "No First Use and NATO's Nuclear Posture," in John D. Steinbruner and Leon V. Sigal, eds., *Alliance Security* (Washington, D.C.: Brookings Institution, 1983), p. 108.

2. John Barry and Russell Watson, "Can Europe Stand on Its Own Feet?" *Newsweek* (December 7, 1987), p. 37.

3. John C. F. Tillson IV, "The Forward Defense of Europe," *Military Review* (May 1981), p. 70.

points where Pact vehicles would be slowed or stopped, offering lucrative targets for NATO artillery and aircraft.

It is impossible to calculate with precision the delay that such barriers would create. Factors such as how well the Pact forces are prepared to breach the obstacles, how much information they have as to the obstacles' locations, and how well NATO can protect the obstacles will determine their effectiveness. Delay could be as short as several hours, which would have little effect on the conventional balance. On the other hand, an extensive network of barriers could plausibly cause a delay of two to three days. John Tillson, who proposed the 40-kilometer-wide defensive zone, estimated that a delay of up to seven days could result from this rather ambitious plan.

If the advance of attacking Pact forces were slowed, then force ratios would be shifted modestly in NATO's favor early in a conflict because NATO would have more time to bring its operational reserve forces to where they are needed. Although the static method does not lend itself to analyzing the impact of barriers--because barriers really only play a role once one side decides to attack and initiates hostilities--it can be artificially modified to reflect their effect. By assuming that a network of defensive barriers--such as the one proposed by Tillson, but only half as wide--could cause a three-day delay in the Pact's ability to bring forces into direct contact with NATO forces, thereby giving NATO three days to bring in reinforcements, a relative shift in the two sides' positions could result. This shift would be more noticeable in the first few days after mobilization when the Pact has a larger advantage (see Figure 8).

The dynamic method should reflect the impact of barriers more accurately than the static method, since barriers would affect the actual conduct of war. Figure 9 shows the results of the dynamic analyses of simulated Pact attacks against the U.S. V Corps and a corps in NATO's Northern Army Group (NORTHAG)--such as the British I Corps or the West German I Corps--initiated four days after the start of mobilization.4/ Based on these dynamic analyses, barriers

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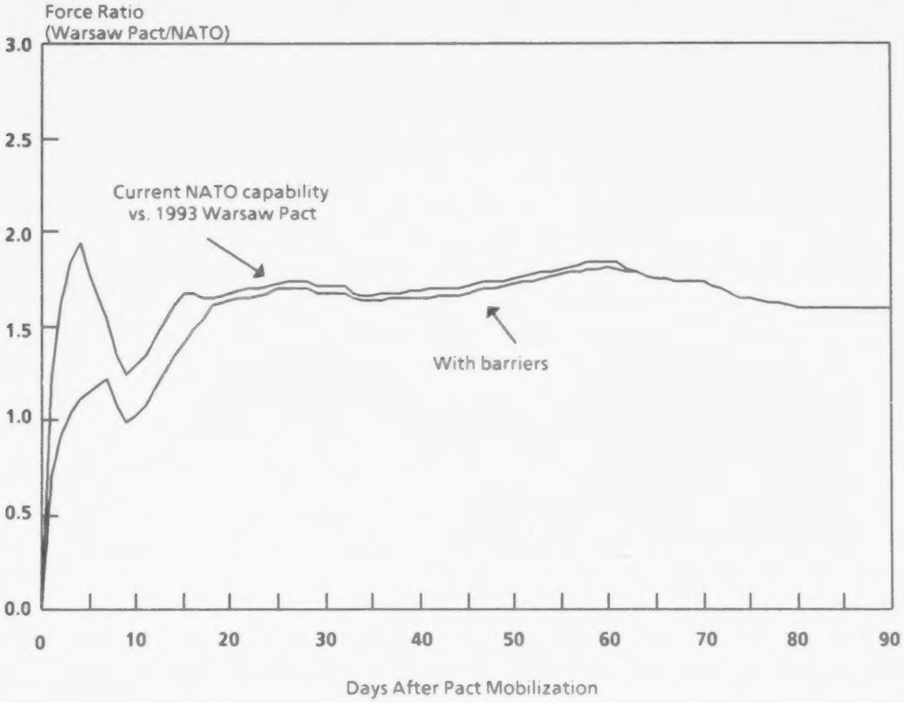
4. The dynamic simulations used in this chapter to compare alternatives for improving NATO's conventional capabilities are based on a slightly different distribution of NATO and Warsaw Pact

(Continued)

Figure 8.
Effect of Barriers on Theaterwide Force Ratios



SOURCE: Congressional Budget Office based on Department of Defense data and on John C.F. Tillson IV, "The Forward Defense of Europe," *Military Review* (May 1981), p. 66.

could significantly reduce the territory lost in each of these two NATO corps. A similar simulation of a Pact attack at 15 days after mobilization yielded no discernible benefit attributable to barriers, however. Although this dynamic model may not be able to capture adequately

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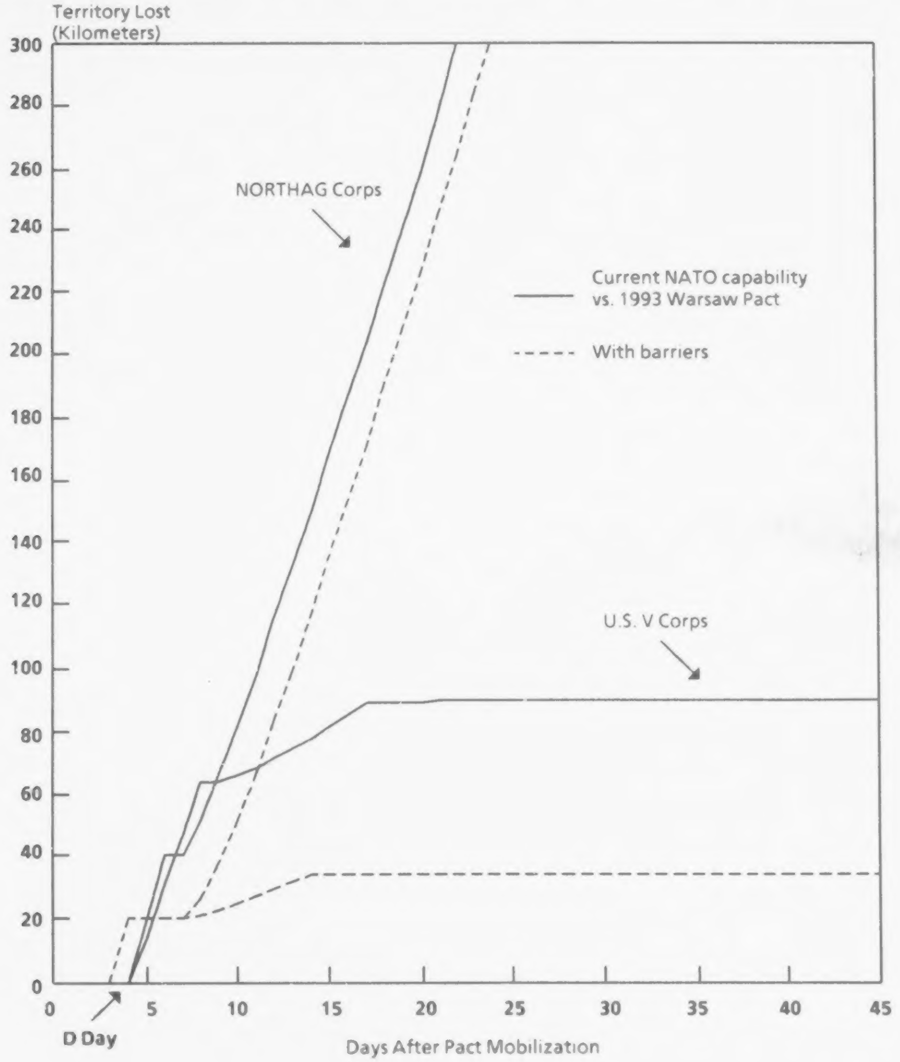
4. Continued

forces than those discussed in the previous chapter. First, all NATO reinforcements arriving in theater after the attack begins (D-Day) are assumed to go to NORTHAG where the force ratios appear to be overwhelmingly in the Pact's favor. Second, the Pact forces are deployed in echelons, in order to represent more accurately what is known about Soviet war-fighting doctrine. Thus, only those front-line Pact forces in the first echelon that would actually take part in direct combat are included in the Pact forces used to determine the Pact/corps force ratios.

Figure 9.
Simulated Effect of Barriers on Territory Lost in Two NATO Corps
(War starts four days after mobilization)



SOURCE: Congressional Budget Office based on Department of Defense data and on John C.F. Tillson IV, "The Forward Defense of Europe," *Military Review* (May 1981), p. 66.

the effect of a barrier such as the one postulated here, it is not surprising that barriers would have a greater impact against a Pact attack initiated early in its mobilization. Indeed, the static analysis also predicted that the largest impact of erecting defensive barriers would be felt if the Warsaw Pact attacks soon after it starts to mobilize and before NATO has the chance to muster many of its forces.

The costs of such a network of barriers should be relatively modest. An extensive network, such as the one proposed by Tillson but only half as wide, could cost up to $5 billion to construct. William Kaufmann, who proposed a more modest and narrower barrier, estimated that the total cost of deploying such devices as mines, tank traps, and sensors to detect advancing enemy vehicles would be between $700 million and $800 million.5/ The political costs of some types of barriers could, however, be high. German political leaders have opposed barriers along the inter-German border in the past because they tend to emphasize the existence of two separate Germanys. Some types of barriers might arouse additional political opposition because they radically alter the environment along the German border, although less obtrusive barriers might avoid these problems.

ALTERNATIVE II: IMPROVE NATO'S CAPABILITY IN CLOSE COMBAT

While barriers could cause important delays, they would not actually destroy any enemy forces. Purchasing more advanced weapons, however, would increase NATO's conventional capabilities to destroy enemy forces. This alternative therefore focuses on weapons involved in close combat--that is, combat that occurs near the front lines between two opposing combatants who typically can see each other. This alternative is limited to increasing the purchases of U.S. weapons, since those are the weapons under the control of the Administration and the Congress.

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5. William W. Kaufmann, "Nonnuclear Deterrence," in John D. Steinbruner and Leon V. Sigal, eds., *Alliance Security* (Washington, D.C.: Brookings Institution, 1983), p. 65.

The U.S. Army has undertaken and largely completed a major modernization effort that began in the early 1980s. As part of that effort, the Army fielded a new main battle tank, the M1, which was followed by a modified version, the M1A1; a new armored personnel carrier, the Bradley fighting vehicle (BFV); a new multiple rocket launcher, the Multiple Launch Rocket System (MLRS); and a new combat helicopter, the AH-64 Apache. Each of these systems is considered by many analysts to be the best of its kind in the world.

This alternative would increase U.S. capability in close combat by equipping all of the Army's approximately 3,270 M1s with a 120mm gun and purchasing an additional 2,970 M1A1s, 4,834 BFVs, and 900 AH-64s. It would purchase sufficient MLRS launchers, rockets, and support equipment for an additional 15 MLRS battalions, and 562 Air Defense Antitank System (ADATS) launchers and associated missiles to equip all 10 of the active U.S. Army heavy divisions. Finally, as an interim solution to the antitank deficiency in Army infantry units, this alternative would also purchase 100,000 improved medium antitank missiles with 7,000 launchers plus 197,000 light antitank (AT-4) missiles.

Specific Weapons Programs to Improve NATO's Close-Combat Capability

Although the Army began fielding the original version of the M1 tank with its 105mm gun in 1981, it later developed a larger 120mm tank gun that would be better able to destroy the newest Soviet tanks equipped with improved armor. Starting in 1985, the M1A1 tank was produced with a 120mm gun. Nevertheless, the Army still owns about 3,270 M1 tanks with the smaller gun. Equipping these tanks with the 120mm gun would improve their ability to counter some of the more modern Soviet tanks, thus increasing the overall capability of U.S. tank forces.

Purchases of some other modern weapons still have not met the Army's acquisition objectives. Although the Army started purchasing the M1 tank in 1979, the Bradley fighting vehicle in 1980, and the Apache helicopter in 1982, it has not yet purchased enough of these systems to fulfill all of its requirements. To equip all of the heavy divisions and brigades intended for use in NATO and to fill its war reserve stocks, the Army could use an additional 2,970 M1A1 tanks and 4,834 more Bradley fighting vehicles. An additional 900 AH-64 helicopters beyond those purchased through 1988 would be needed to equip all of the active Army units that would be sent to Europe.

New programs planned for production during the next five years will also increase combat capability. The Army's plans to improve the air defense capability of its heavy combat units were halted with the cancellation of the DIVAD (Division Air Defense) antiaircraft gun program in 1985. Since then the Army has looked for a replacement, recently settling on Martin Marietta's Air Defense Antitank System. Deployment of this missile system with the heavy divisions will greatly improve the air defense capability of the Army's units in Europe.

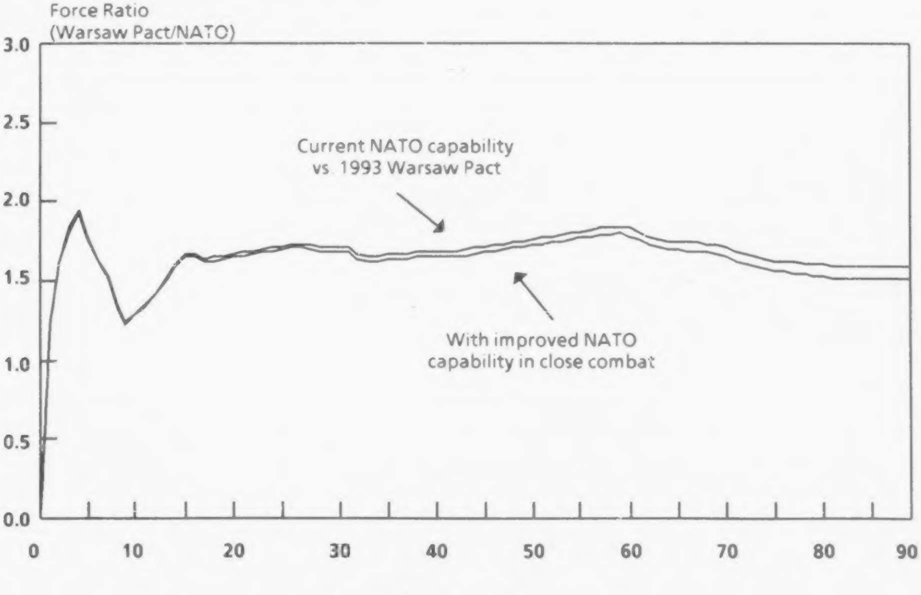
Fielding an effective antitank weapon for infantry units has also been a problem for the Army. Replacing the current Dragon medium antitank missile and the Light Antitank Weapon (LAW) with more effective weapons would significantly improve the infantry's antitank capability. Although the Army has not yet picked replacements for these weapons, it is considering several medium antitank weapons including the Milan, the Bill, and an improved Dragon to replace the current Dragon. A production decision for a replacement is expected in 1992. The Army is also purchasing the AT-4 light antitank missile to replace the LAW in its infantry divisions.

Finally, measures could be taken to mitigate the Warsaw Pact's numerical superiority in artillery weapons. (The 1987 version of the Department of Defense's *Soviet Military Power* credits the Pact with 42,000 artillery pieces compared with NATO's 18,350.) Greatly increasing the number of deployed U.S. artillery weapons would require more personnel, an approach not considered in this alternative. Nonetheless, the number of Army artillery pieces could be increased by reassigning artillery soldiers currently serving in Pershing missile units that will be deactivated as a result of the Intermediate-Range Nuclear Forces Treaty. Specifically, the approximately 6,800 U.S. soldiers in Pershing missile units could be reassigned to form 15 additional artillery battalions armed with the Army's most modern artillery weapon, the Multiple Launch Rocket System. These units could be assigned to the U.S. III Corps, which is not responsible for the defense of any particular sector of the inter-German border (see Figure 4 in Chapter II). Rather, its mission is to act as a reserve for all of the northern half of the central region (NORTHAG). In this way, some additional forces could be added to NORTHAG's less heavily defended sector.

Improvement in Capability

Despite the many changes suggested by this alternative, the resulting improvement to NATO's theaterwide capability relative to that of the Warsaw Pact might be small. Based on the WEI/WUV analysis described in Chapter II, these improvements would lead to only a 2 percent improvement in the Pact/NATO force balance 60 days after mobilization (see Figure 10). There are two reasons for this small

Figure 10.
Effect of Improved Close-Combat Capability on Theaterwide Force Ratios



SOURCE: Congressional Budget Office based on Department of Defense data.

effect. First, U.S. forces account for only half of NATO's total; therefore, any improvement in U.S. capability will be diluted by a factor of two unless other NATO nations also improve their forces. Second, as a result of the U.S. Army's recent modernization effort, U.S. ground forces are, on the whole, already very capable, particularly those stationed in Europe. For example, many of the U.S. Army units stationed in Europe during peacetime already have the new M1A1 tank. Similar situations prevail for other types of equipment in U.S. units in Europe, such as the Bradley fighting vehicle and the AH-64 helicopter. But gains would also be made in other aspects of close combat. For example, the improved air defense and antitank capability that would result from this option leads to a 3 percent increase in the capability of active heavy divisions. Nonetheless, most forces that bear heavily on the outcome of a conflict in Europe would not have their capability augmented substantially.

This option would lead to larger improvements in the capability of other U.S. divisions that do not figure heavily in the balance in Europe. WEI/WUV analysis shows that the capability of active infantry units would increase between 5 percent and 10 percent because they would get better antitank weapons and helicopters. But these units are not ideally suited for heavy combat in Europe and provide only a small portion of the total U.S. forces scheduled for deployment to Europe during a crisis. A few heavy units in the U.S. reserves would realize substantial gains in capability--as much as 31 percent. But they are scheduled to arrive in the European theater between 60 and 80 days after Pact mobilization and account for only 2 of the 26 armored division equivalents contributed by the United States, which reduces the significance of any improvement they might realize.

Nor would this option result in substantial improvements in particular corps areas, even though disparity in vulnerability among corps was identified as a key problem in Chapter II. Increases in capability would be somewhat larger in U.S. corps since the improvements are restricted to U.S. forces. Static WEI/WUV analyses reflect a 6 percent improvement in the capability of the U.S. V Corps, which is located in the central portion of West Germany. But, as noted in the preceding chapter, the most serious concerns revolve around corps in the northern section.

Even ruling out fundamental redeployment of NATO assets, this option might improve capability in the NORTHAG corps. For example, by deploying the 15 additional MLRS artillery battalions created under this option to the U.S. III Corps located in the northern area, NATO could achieve a 5 percent improvement in the capability of two of NORTHAG's front-line corps 60 days after mobilization. (This estimate assumes that the U.S. III Corps' 15 MLRS battalions are evenly divided between the British I Corps and the West German I Corps, because these two NORTHAG corps are opposite the likely corridors of attack by Pact forces.) But the improvements would still be modest.

The effects of this alternative on particular corps are confirmed by dynamic analyses.6/ Results of simulations using the dynamic model indicate that the standing of the U.S. V Corps relative to the Pact is improved by 4 percent (see Figure 11), compared with the 6 percent overall improvement that resulted using static WEI/WUV methods. The simulations also indicate that the defensive posture of two NORTHAG corps would be improved by 10 percent (see Figures 11 and 12), about twice the improvement that resulted using the static technique. It must be kept in mind, however, that the relatively large improvement in the two corps in NORTHAG and comparatively small improvement indicated in the U.S. V Corps do not change the ultimate outcome in any way: the situation in NORTHAG is still bleak, and the U.S. corps was already strong.

Even though this alternative would not add greatly to NATO capability, either in key corps sectors or theaterwide, the Administration and the Congress might wish to consider it for other reasons. Indeed, the Administration has proposed buying substantially more M1A1 tanks in coming years. Such an action would enhance capabili-

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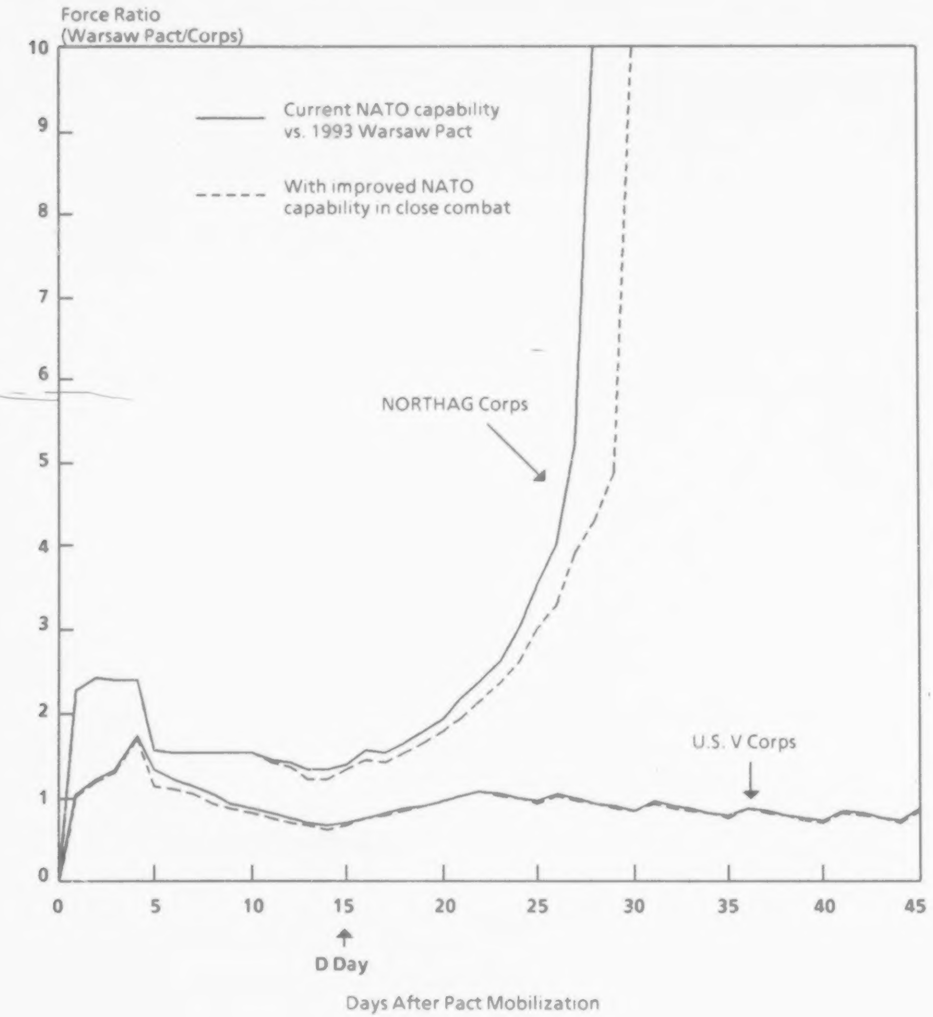
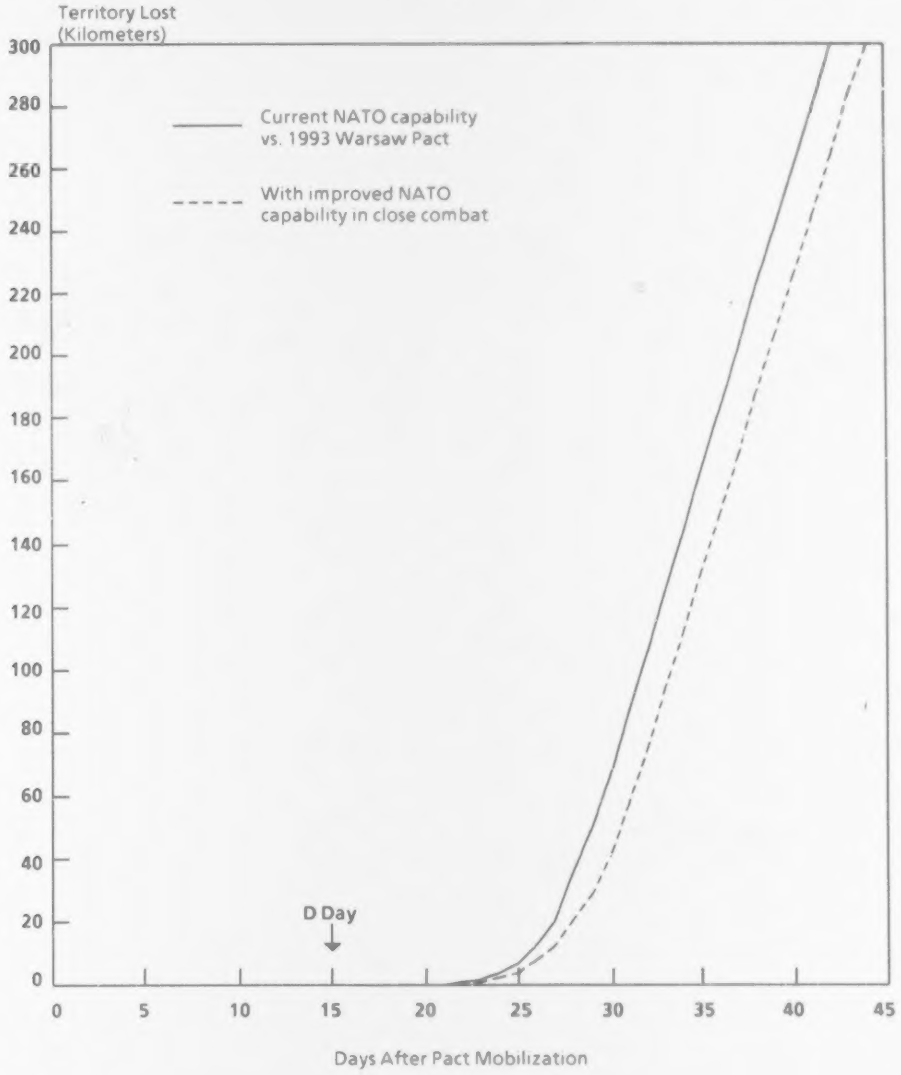
6. The standards used to measure improvements based on the dynamic analysis differ somewhat from those used for the static analysis. In the latter case, force ratios at 60 days after mobilization were used as a standard. In the dynamic analysis, however, the NORTHAG corps were sometimes overrun by this stage, based on the war starting at 15 days after mobilization. Comparisons using the results from the dynamic analysis are therefore based on conditions after 30 days of combat, which corresponds to 45 days after mobilization. The primary standard of comparison for the dynamic analysis is territory lost in each corps. The U.S. V Corps loses no territory, even without improvements, however. The impact of the various alternatives in this corps is therefore based on reductions in force ratio.

Figure 11.
Simulated Effect of Improved Close-Combat Capability on Force Ratios in Two NATO Corps



SOURCE: Congressional Budget Office based on Department of Defense data.

Figure 12.
Simulated Effect of Improved Close-Combat Capability on Territory Lost in a NORTHAG Corps



SOURCE: Congressional Budget Office based on Department of Defense data.

ties of units--particularly reserve units--that could be increasingly important during a lengthy NATO conflict. Moreover, implementing the portions of this alternative that call for production of new weapons--such as the tank and helicopter--would keep open weapons production lines and so would allow the United States to produce weapons more quickly in time of war.

Costs

The total cost of all the weapons purchased under this option would amount to $41 billion (see Table 6). The largest portion of these costs results from the purchase of large numbers of AH-64 helicopters, M1A1 tanks, and ADATS. Costs of new MLRS launchers and fighting vehicles also contribute substantially to the total. Some additional funds might be needed to operate and maintain these weapons, which are newer and more complicated than the weapons that they would replace. Over the typical 20-year life of a weapon, these costs could become significant. Indeed, the additional operating and support costs associated with these weapons for the next 20 years could be as high as $7.5 billion (in 1989 dollars). The total cost of this alternative, including both investment and operating costs, would be $48.4 billion.

ALTERNATIVE III: ADD FORCES TO NATO

Rather than provide more and better weapons to existing forces, the Congress could increase NATO's ground force capability by funding additional U.S. forces for Europe's defense. Since it is impossible to determine "how much is enough" in terms of combat power, this alternative would simply add as many combat divisions to NATO's force structure as could be equipped for the same total cost as the previous alternative. Doing so allows a direct comparison between the effects of the two options. For the $48.4 billion needed to carry out Alternative

TABLE 6. COSTS OF IMPROVING CLOSE-COMBAT CAPABILITY IN ALTERNATIVE II (Costs in millions of fiscal year 1989 dollars of budget authority)

	1989	1990	1991	1992	1993	Subtotal 1989-1993	1994-2008	Total 1989-2008
M1A1 Tank								
Quantity	545	665	855	905	0	2,970	0	2,970
Cost	1,720	2,310	3,140	2,630	0	9,800	0	9,800
MI Tank Modification								
Quantity	150	300	600	600	600	2,250	1,020	3,270
Cost	100	150	300	300	300	1,150	500	1,650
Bradley Fighting Vehicle								
Quantity	660	720	792	792	792	3,756	1,078	4,834
Cost	800	850	800	800	800	4,050	1,100	5,150
AH-64 Apache Helicopter								
Quantity	84	108	144	144	144	624	276	900
Cost	1,150	1,400	1,850	1,850	1,800	8,050	3,450	11,500
Improved Medium Antitank Missile System								
Missiles	7,200	14,400	15,680	15,680	15,680	68,640	31,360	100,000
Launchers	180	360	720	1,000	1,580	3,840	3,160	7,000
Cost	100	200	300	350	450	1,400	850	2,250
Improved Light Antitank Weapon (AT-4)								
Quantity	77,000	75,000	45,000	0	0	197,000	0	197,000
Cost	70	50	30	0	0	150	0	150
Air Defense Antitank System								
Missiles	60	424	669	827	810	2,790	7,144	9,934
Launchers	5	20	38	47	46	156	406	562
Cost	160	400	400	400	400	1,760	3,700	5,460
Multiple Launch Rocket System								
Rockets	72,000	72,000	72,000	72,000	72,000	360,000	224,500	584,500
Launchers	72	72	72	72	72	360	424	784
Cost	550	550	550	500	600	2,750	2,250	5,000
Total								
Acquisition Costs a/	4,650	5,910	7,370	6,830	4,350	29,110	11,850	40,960
Operating and Support Costs b/	0	0	30	80	150	260	7,230	7,490
Acquisition and Operating and Support Costs	4,650	5,910	7,400	6,910	4,500	29,370	19,080	48,450

SOURCE: Compiled by the Congressional Budget Office based on Department of Defense data.

a. Acquisition costs include procurement, research, development, test and evaluation, and military construction costs associated with acquiring the system.

b. Operating and support costs include only the marginal increase in costs associated with substituting the systems included in this alternative for current systems.

II, the United States could equip with modern equipment and maintain through the year 2008 only one active heavy division.[7]

Adding one heavy division to the U.S. Army means buying more tanks, fighting vehicles, helicopters, and many other types of equipment. The initial investment costs for the division's equipment alone would total $5 billion. The division presumably would be based in the United States, since the Congress has generally prohibited any increases in U.S. forces stationed in Europe. Enabling this additional division to deploy to the central region quickly in the event of a crisis means that the United States would also have to preposition overseas an additional division's worth of equipment. This would result in an added cost of $3.6 billion. Altogether, the investment costs for this new unit could total $8.6 billion.

Unlike the previous two options, this one would also add substantially to annual operating costs. The additional operating costs would be lower if the new division were created from reserve forces, since fewer full-time soldiers would be needed. One could argue, however, that a reserve division would contribute less to NATO's defense than an active division, since it probably could not be ready for combat with fewer than 30 days to mobilize. In this alternative, therefore, the extra division is added to the active forces.

Assuming no increase in costs to recruit and retain needed personnel, the extra 16,000 military personnel needed for the additional division plus the other associated operating costs would total $1.8 billion a year once the division is fully operational. (These estimates of added personnel assume that the only additions are those needed to fill the division. No increase is assumed in personnel for overhead and support, although another 12,500 soldiers could be required to provide combat and tactical support.) These operating costs could well be

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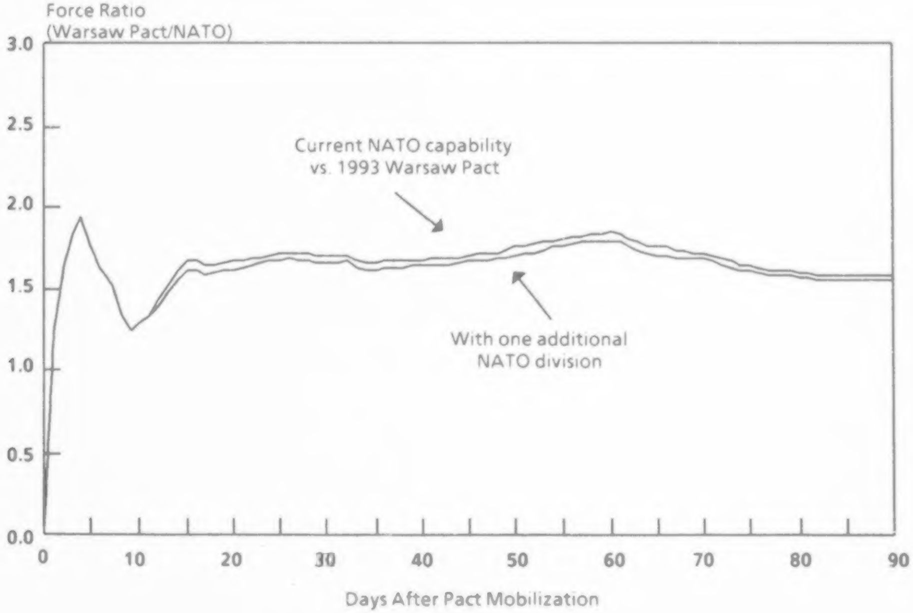
7. It is not clear that this modest increase in NATO's forces would affect the theaterwide balance in any significant way. The Chairman of the House Committee on Armed Services has argued that a large number of additional divisions might be needed to increase substantially NATO's conventional capability--perhaps as many as 10 divisions. (See Congressman Les Aspin, "The World After Zero INF.") Aspin was also quoted as saying that the added investment costs of 10 extra divisions could total about $75 billion, with added operating costs of up to $20 billion a year. (See "West Requires New Arms to Alter Soviet Strategy," *Defense News*, October 5, 1987, p. 1.) According to CBO's analysis, adding 10 divisions would also mean adding 160,000 people to the Army just to fill out the divisions. This might well require a return to some form of conscription since it would be difficult, at any reasonable pay rates, for the all-volunteer force to provide enough recruits for such a large Army.

higher if the Army must incur extra recruiting costs to induce enough people who meet its current high-quality standards to join the larger Army. In any case, the operating and support costs associated with this alternative could total $32.6 billion by 2008. The total cost of carrying out this alternative, then, would be slightly less than that of Alternative II--about $41 billion.

The impact of one additional NATO division differs, depending on whether its contribution is viewed from the perspective of the entire theater or of a particular corps. Based on costs through the year 2008, adding one division theaterwide does not appear to be any more cost effective than buying more weapons for close combat, as proposed in the previous alternative (see Figure 13). Both alternatives would

Figure 13.
Effect of Additional NATO Forces on Theaterwide Force Ratios



SOURCE: Congressional Budget Office based on Department of Defense data.

require about the same investment and would reduce the theaterwide Pact/NATO force ratios only slightly. Specifically, this alternative would reduce the theaterwide force ratios by the same amount--2 percent--that resulted from Alternative II.

Allocating the extra division to NORTHAG and to those NATO corps currently at a numerical disadvantage, however, yields a much greater impact on the balance within a specific corps. (On the other hand, it would be difficult to concentrate all of the improvements resulting from the previous alternative in one or two of the non-U.S. corps in NORTHAG because allied troops are not familiar with U.S. weapons.) For example, providing additional reinforcements to two NORTHAG corps--equal to one-half of the extra division to each corps--would reduce territory lost by 14 percent compared with a reduction of 10 percent under the previous alternative (see Figure 14). Nevertheless, one additional division would probably not be sufficient to bring all of NATO's individual corps up to a level that would provide great confidence throughout the theater. Thus, it is not clear whether this alternative or the previous one would be a more cost-effective solution.

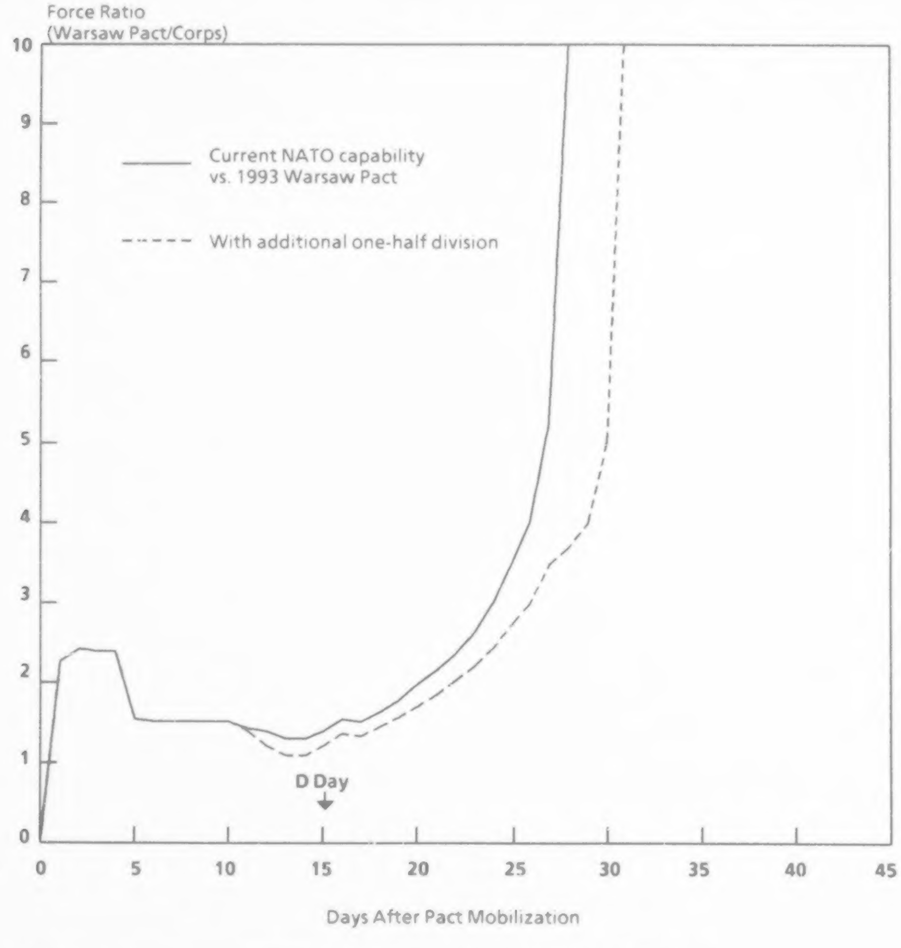
Adding a division to U.S. forces runs directly counter to current Army budget trends. In its 1989 budget, the Army reduced the number of people on active duty by 8,600. Thus, it might be politically difficult to increase the number of divisions in the Army, even if there were agreement that conventional capability should be increased in this way.

ALTERNATIVE IV: EMPHASIZE ATTACK OF FOLLOW-ON FORCES

Instead of enhancing its combat capability at the front lines, NATO could try to prevent the Pact from bringing all of its reinforcing units into the central theater. This is the philosophy behind NATO's strategy of attacking the Pact's reinforcing or follow-on forces, a strategy known as FOFA (for follow-on forces attack). Specifically, this alternative would attempt both to delay the arrival of the Pact's reinforcements in theater by attacking rail lines and bridges in eastern Europe and to attack and destroy the follow-on or "second-echelon" combat units themselves as they move closer to the front.

Unlike the previous three alternatives, FOFA is a long-term approach that would not offer significant improvements in capabilities

Figure 14.
Simulated Effect of Additional NATO Forces on Territory Lost in a NORTHAG Corps



SOURCE: Congressional Budget Office based on Department of Defense data.

until the mid- to late 1990s. FOFA also involves weapons that have not yet been tested and, in some cases, have not yet been developed fully. For this reason, the ultimate effectiveness and cost of this strategy are somewhat uncertain at this point. In addition, development problems could delay the realization of the benefits of FOFA to some time in the next century.

This study, therefore, makes conservative assumptions about the potential capability of the weapons needed to carry out FOFA. FOFA also differs from the previous three alternatives in that it is a relatively new strategy and also very complex, involving multiple weapons systems from both the Army and Air Force. Since a full discussion of FOFA, including its architecture, benefits, drawbacks, and costs would be rather lengthy, this chapter provides only an outline of FOFA's benefits, costs, and limitations. The abbreviated discussion will highlight points that enable the reader to compare this alternative with the previous three. A full discussion of the specific missions inherent in FOFA, the existing and future systems needed to carry out those missions, the study's assumptions of how the missions would be accomplished, and the detailed analysis of the impact of successful FOFA missions are included in Appendix D.

If the necessary weapons work and are deployed, FOFA could improve conventional capabilities in two ways. It could delay the arrival of the enemy's follow-on forces, giving NATO more time to muster its own reserves. It could also actually destroy these follow-on forces before they arrive at the front, thereby permanently improving the balance of forces. These two approaches are discussed separately.

Delaying Follow-On Forces

Soviet units that are based in the Soviet Union in peacetime would constitute slightly more than half of the total Pact forces that might eventually fight in the central region. Some of these units are maintained at a combat-ready status even in peacetime and could arrive in theater very quickly--within 7 to 15 days after mobilization begins. Others might not be ready for combat until 60 to 90 days after mobilization. Once ready, these units would have to travel from their permanent locations in the Soviet Union to the area near the inter-German border.

Attacking the relatively sparse rail and highway network in eastern Poland could greatly hinder Soviet troop advances. Recent studies by the Office of Technology Assessment and the RAND Corporation have suggested that long-range, air-launched, conventionally armed cruise missiles could destroy bridges and rail lines in eastern Europe.[8] (Cruise missiles travel long distances at relatively low speeds and at low altitude.)

By attacking the major rail bridges, transloading areas, and the Polish and East German rail networks, the arrival of the last Soviet unit could be delayed up to three weeks, slipping it from 60 days after mobilization to 81 days and reducing the arrival rate from an average of one division every 1.5 days to one division every 2.1 days.[9]

Destroying Follow-On Forces

Another goal of FOFA would be to destroy some of the Soviet reinforcing units before they arrive in theater. Whereas some of the attacks aimed at delaying Soviet reinforcements would be made at distances of more than 600 to 850 kilometers from the inter-German border and U.S. bases, attacks aimed at destroying combat units could be made efficiently only at shorter ranges. Pact forces, when on the offensive, typically attack in waves known as "echelons." The day before they are committed to battle, Pact divisions in the second or follow-on echelon would move from divisional assembly areas--about 80 kilometers from the forward edge of battle--to regimental assembly areas 50 kilometers closer to the front lines. Each division would include over 3,000 vehicles, but only about 750 of these would be combat vehicles such as tanks, armored personnel carriers, and artillery pieces. These 750 combat vehicles are the primary targets of FOFA.

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[8] Office of Technology Assessment, *New Technology for NATO: Implementing Follow-On Forces Attack* (OTA-ISC-309, June 1987); Stephen T. Hosmer and Glenn A. Kent, *The Military and Political Potential of Conventionally Armed Heavy Bombers*, R-3508-AF (Santa Monica: RAND Corporation, August 1987).

[9] The impact of attacks on the eastern European rail network would be, to some extent, a function of when the attacks were initiated. If they did not begin until 15 days after the Pact started to mobilize (an oft-mentioned point for hostilities to begin), most of the units from Poland and Czechoslovakia would already be in theater, and only those forces from the central military districts of the Soviet Union would still be in transit.

Unlike bridges and rail lines whose locations are known during peacetime, combat units in transit must be found before they can be attacked. Thus, destroying Pact reinforcing units before they reach the front lines requires systems to detect the units as well as weapons to attack enemy troops at long distances.

System Design. To detect enemy reinforcements, the United States currently is developing the Joint Surveillance and Target Attack Radar System (JSTARS). This airborne radar, if it performs as planned, should be able to locate enemy units up to 300 kilometers behind the forward edge of battle. To destroy the vehicles within these units, the Army is developing a tactical missile, called the Army Tactical Missile System (ATACMS), capable of attacking targets to a range of 150 kilometers behind enemy lines. The version of ATACMS most suited for destroying armored vehicles will carry antiarmor submunitions that are guided to their targets by individual sensors. These small bombs, known as "smart" submunitions because they seek out and attempt to destroy a target on their own, are designed specifically for attacking armored vehicles at long ranges.

Capability to Destroy Vehicles. How many Pact reinforcements could NATO destroy using JSTARS for detection and the ATACMS missile for attack? The actual amount depends on many conditions that, for the purpose of this study, can only be assumed. These conditions include JSTARS' ability to detect major Pact units as they move, the density of high-value targets like tanks within these units, and the number of vehicles that could be destroyed by each ATACMS missile.

This study assumed that the JSTARS radar, complemented by other existing NATO systems, would be able to detect each division as it moved from its divisional assembly area to its regimental assembly areas.[10] The assumptions concerning the effectiveness of each ATACMS missile carrying antiarmor submunitions were based on an evaluation by Steven Canby that concentrated on the problems associated with the FOFA approach.[11] Thus, each missile was assumed to destroy, on average, two vehicles per attack. Although other analysts have made more optimistic evaluations of the ATACMS' effectiveness, Canby's conservative assumptions were used in this study to see if FOFA would be a worthwhile strategy, even under less favorable conditions.12/ This study, which allotted one missile to every 10 vehicles in a division, concluded that FOFA could ultimately destroy 20 percent of the combat capability of each reinforcing Pact division as it makes its transition.

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[10] This transition, according to a recent OTA report, would take six to eight hours. See Office of Technology Assessment, *New Technology for NATO*, p. 84.

[11] Steven L. Canby, "The Operational Limits of Emerging Technology," *International Defense Review* (June 1985), p. 878.

Effect on Theaterwide Capability

Coupled with the potential for delaying units discussed above, this capability to destroy enemy units could have a substantial effect on the theaterwide balance of forces. This study assumes that the United States, perhaps in conjunction with its NATO allies, makes the large investment in FOFA weapons necessary to attack each Pact reinforcing division as it moves from its divisional assembly area. Since some Warsaw Pact divisions will already be at the front when NATO begins its attack of follow-on forces (presumably on D-Day), NATO would be able to attack only about 60 percent of all the Pact units before they reach the front lines.

It is unlikely that NATO would attack Pact reinforcements, or perhaps even rail networks, before an actual invasion and onset of hostilities. For this reason, an assessment of FOFA's impact theaterwide, which uses the static method and is based on destroying some Pact forces before they arrive at the front and on delaying the arrival of others, would be somewhat misleading, since it assumes no losses resulting from direct combat. For this application, therefore, the dynamic analyses within the corps areas are probably more relevant.

To establish FOFA's impact throughout the theater, dynamic analyses were conducted within each of the three corps--the British I Corps, the West German I Corps, and the U.S. V Corps--assumed to face a main attack by Pact forces. The combined results of the dynamic analyses within these three corps serve as a proxy for a

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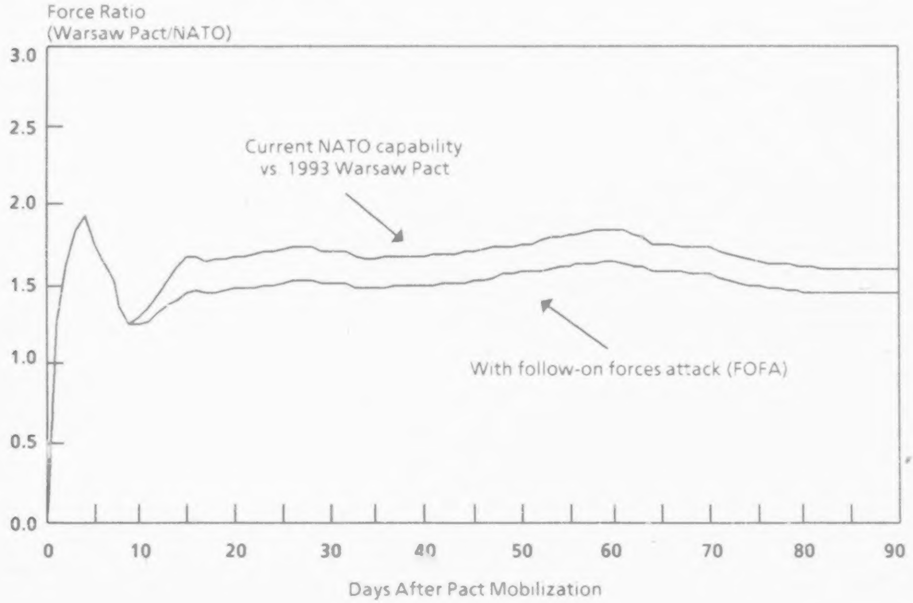
12. For example, the Institute for Defense Analyses estimated that each ATACMS missile equipped with 20 antiarmor submunitions could destroy between three and seven vehicles. See Institute for Defense Analyses, *Follow-On Force Attack*, R-302, vol. I (Alexandria, Va.: IDA, April 1986), p. III-4.

theaterwide analysis. These analyses indicated that the FOFA strategy could have the same effect within the three corps facing a major attack as adding two divisions to each of the two NORTHAG corps, and one division to the U.S. V Corps. The theaterwide impact of FOFA, therefore, would appear to be equivalent to having five additional NATO divisions in theater by D-Day--assumed to be 15 days after mobilization. Such a contribution would have a significant effect on the balance of forces at the front (see Figure 15).

Figure 15.
Effect of Follow-On Forces Attack (FOFA)
on Theaterwide Force Ratios



SOURCE: Congressional Budget Office based on Department of Defense data and on Office of Technology Assessment, *New Technology for NATO: Implementing Follow-On Forces Attack* (OTA-ISC-309, June 1987).

Effect on Corps Capability

FOFA would, of course, offer the greatest benefit if all NATO countries invested in FOFA assets. But FOFA offers an advantage largely unavailable under previous alternatives: it can significantly improve capability even in those corps where FOFA systems, such as ATACMS, are not deployed. Given the wide disparity in capability among NATO corps, that could be an important advantage. For example, even if only the United States invested in FOFA, the impact would be felt in non-U.S. corps for two reasons. First, attacks on bridges and railroads would delay Pact reinforcements throughout the theater, not just those opposite U.S. corps. Second, the ATACMS missile has a range sufficient to attack Pact reinforcements opposing neighboring NATO corps as well as those attacking corps in which the launcher is deployed. Thus, ATACMS missile launchers associated with U.S. III, V, and VII Corps should be able to attack reinforcing Pact units facing any of the eight corps in the central region.13/ As a consequence, the force balance in all of the corps within the central region could be greatly improved.

Even if FOFA assets were not deployed in the front-line corps assigned to NORTHAG, dynamic analyses show that attack by weapons attached to U.S. III Corps could, after 30 days of combat, improve the balance of forces in the NORTHAG corps by 17 percent and reduce territory lost by 16 percent (see Figures 16 and 17). An improvement of approximately 28 percentage points could also occur in the U.S. V Corps. The analysis suggests, however, that significant problems could still remain in some corps, such as those in NORTHAG, even with FOFA. Thus, FOFA alone may not be able to solve NATO's theaterwide problems.

Costs of FOFA

The benefits of a FOFA strategy would not come cheaply. The major cost associated with FOFA is the development and procurement of ATACMS missiles. Attacking one reinforcing division could require

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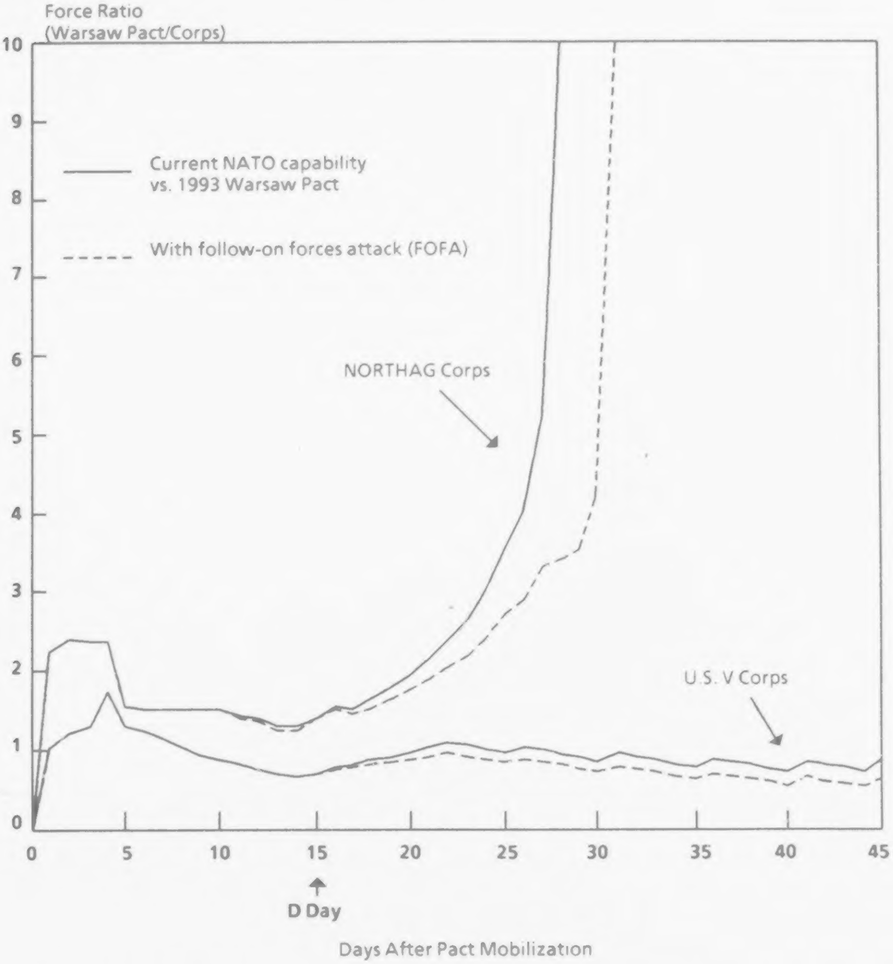
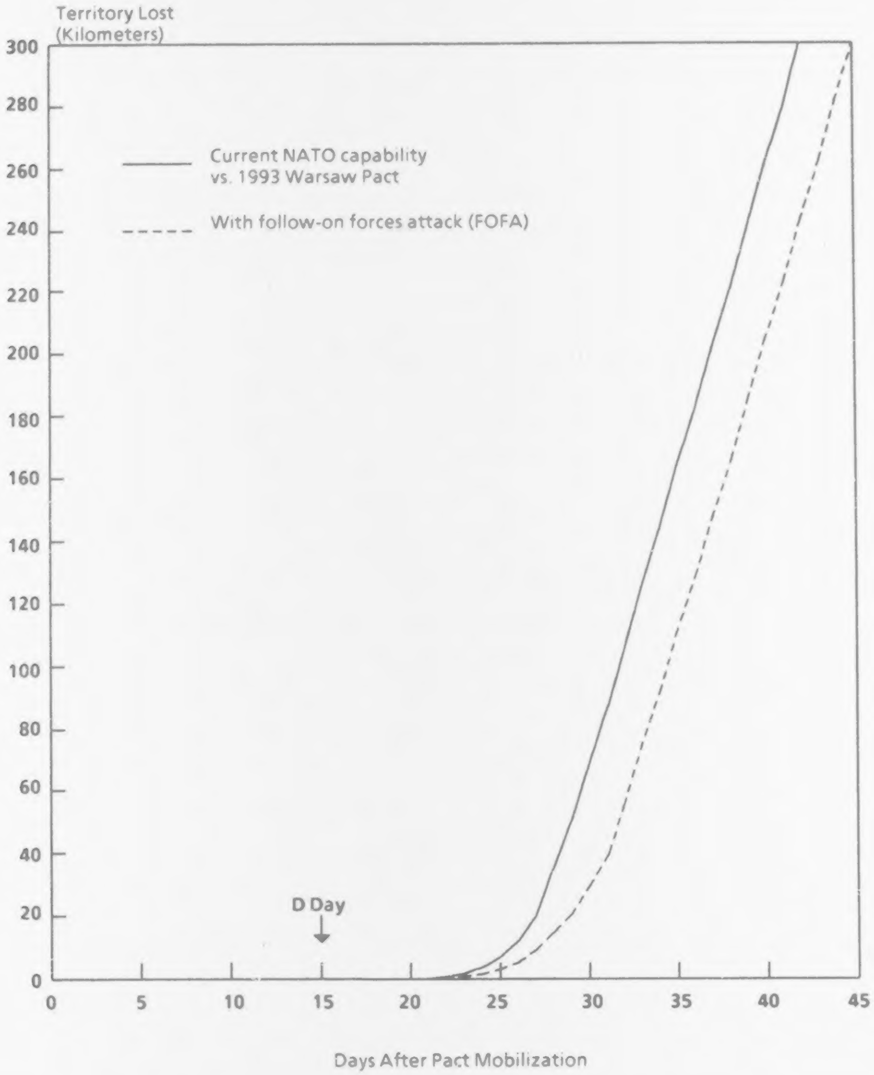
13. Since most U.S. allies equip their forces with MLRS launchers, they could, theoretically, use ATACMS to attack Pact reinforcements.

Figure 16.
Simulated Effect of Follow-On Forces Attack (FOFA) on Force Ratios in Two NATO Corps



SOURCE: Congressional Budget Office based on Department of Defense data and on Office of Technology Assessment, *New Technology for NATO: Implementing Follow-On Forces Attack* (OTA-ISC-309, June 1987).

Figure 17.
Simulated Effect of Follow-On Forces Attack (FOFA) on Territory Lost in a NORTHAG Corps



SOURCE: Congressional Budget Office based on Department of Defense data and on Office of Technology Assessment, *New Technology for NATO: Implementing Follow-On Forces Attack* (OTA-ISC-309, June 1987).

330 ATACMS missiles. The total number that would have to be bought in peacetime and stockpiled for war depends on how soon after mobilization the Pact starts it attack (which influences the number of divisions that could be attacked), how many reinforcing divisions are detected and so could be attacked, and whether the Warsaw Pact holds a large portion of its forces in reserve.

Assuming that Pact forces attack in echelons, and that hostilities commence 15 days after mobilization starts, NATO would require almost 17,500 ATACMS missiles during 30 days of combat to attack all of the Pact reinforcing divisions before they arrive at the front. If FOFA attacks were to start earlier--for example, four days after the Pact starts to mobilize--then more Pact divisions would be in transit, and almost 19,500 ATACMS could be needed to attack them all during 30 days of combat (see Table 7). (Earlier commencement of FOFA attacks, however, would result in greater benefit to NATO, because more Pact reinforcing units would be delayed or destroyed before they reach the front.) At an estimated cost per missile of $1.6 million, the total investment in ATACMS alone needed during the next 20 years could be as much as $18 billion (see Table 8).14/

In order to detect Warsaw Pact units in transit, the United States will need to develop and procure enough JSTARS radars to provide continuous coverage. In addition, the Army might wish to field a remotely piloted vehicle to improve its ability to detect Pact combat vehicles. These expenses could add $6.3 billion to acquisition costs.

Additional funds would be required to purchase and support the cruise missiles needed to achieve the delay of forces discussed above. A RAND report postulates that it should be possible to develop within five years appropriate conventional air-launched cruise missiles for cutting rail lines.15/ The B-52 bombers that would launch the missiles already exist, but each B-52 would have to be modified to carry 12 cruise missiles, at a cost of about $7 million each. Keeping

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14. The $18 billion provides funds to purchase only 11,354 ATACMS, rather than the total 17,500 to 19,500 missiles needed for 30 days of combat. This discrepancy occurs because ATACMS procurement would not begin until 1994. A postulated maximum annual production rate of 880 missiles, coupled with a late start, prevents more missiles from being purchased by the year 2008.

15. Hosmer and Kent, *The Military and Political Potential of Conventionally Armed Heavy Bombers*, p. 35.

TABLE 7. REQUIREMENTS FOR ATACMS MISSILES DURING THIRTY DAYS OF COMBAT

	Days After Mobilization that Follow-on Forces Attacks Start	
	4	15
Number of Reinforcement Divisions Subject to Attack	59	53
Number of ATACMS Missiles Needed	19,470	17,490

SOURCE: Derived by the Congressional Budget Office based on Department of Defense data.

NOTE: Assumes the middle-range scenario described in Chapter II and that the Warsaw Pact attacks in waves or echelons.

ATACMS = Army Tactical Missile System.

the bridges and rail lines closed in eastern Europe for the 60 days or so when Pact reinforcing divisions might be in transit could require approximately 4,000 cruise missiles and 20 B-52s. The acquisition cost, then, of this part of the follow-on forces attack could be $7.5 billion for missiles and $140 million to modify the B-52s. Thus, the total acquisition costs for FOFA could reach $33.3 billion (see Table 8). Additional costs associated with operating and supporting these systems through the year 2008 could be $16.4 billion, bringing the total cost for this alternative to $49.7 billion.

Nor is that necessarily the final bill for FOFA. Costs of systems still in development commonly rise beyond planned levels. Historically, the cost of many systems has increased in real or inflation-adjusted terms by 50 percent to 200 percent from when they begin full-scale engineering development (the stage during which a prototype of the system is produced) to when they achieve initial operating capability.16/ Many components of the FOFA system have not yet reached the point of full-scale engineering development. Thus, costs could increase, and the extent of that increase is not known.

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16. Congressional Budget Office, "Cost Growth in Weapon Systems: Recent Experience and Possible Remedies" (Staff Working Paper, October 12, 1982), p. 2.

TABLE 8. COSTS FOR FOLLOW-ON FORCES ATTACK IN ALTERNATIVE IV (Costs in millions of fiscal year 1989 dollars of budget authority)

	1989	1990	1991	1992	1993	Subtotal 1989-1993	1994-2008	Total 1989-2008
Joint Surveillance and Target Attack Radar System								
Radars	0	0	1	1	8	10	12	22
Ground Stations	0	6	17	14	11	48	38	86
Cost	270	200	300	220	1,410	2,400	2,180	4,580
Remotely Piloted Vehicles								
Quantity	0	26	31	29	26	112	88	200
Cost	100	230	220	290	210	1,050	650	1,700
Army Tactical Missile System a/								
Quantity	0	0	0	0	0	0	11,354	11,354
Cost	100	100	50	50	50	350	17,550	17,900
Multiple Launch Rocket System								
Launchers	44	44	44	44	44	220	428	648
Cost b/	100	100	100	100	100	500	950	1,450
Conventional Air-Launched Cruise Missiles								
Missiles	0	0	0	0	0	0	4,000	4,000
Cost	50	100	150	250	350	900	6,610	7,510
B-52 Modification								
Quantity	0	0	0	3	17	20	0	20
Cost	0	0	10	50	80	140	0	140
Total								
Acquisition Costs c/	620	730	830	960	2,200	5,340	27,940	33,280
Operating and Support Costs	0	20	60	110	170	360	16,040	16,400
Acquisition and Operating and Support Costs	620	750	890	1,070	2,370	5,700	43,980	49,680

SOURCE: Congressional Budget Office based on Department of Defense data; Institute for Defense Analyses, *Follow-On Force Attack*, R-302, vol. V (Alexandria, Va.: IDA, April 1986); and Department of the Army, U.S. Army Concepts Analysis Agency, *Forward of the FEBA Weapon System Cost and Benefit Study (FOFEBA), Phase I*, CAA-SR-81-3 (February 1981).

a. Includes only those funds for the development and procurement of the antiarmor version of ATACMS.

b. Reflects costs for the launcher only.

c. Acquisition costs include procurement, research, development, test and evaluation, and military construction costs associated with acquiring the system.

Risks of Implementing FOFA

The previous discussion of the impact of delaying and attacking Pact reinforcements assumed that the weapons needed to perform this mission would work, at least well enough to be consistent with conservative estimates of performance. None of the systems envisioned in this analysis, however, has yet been produced in large numbers or tested under realistic conditions. Some components, such as JSTARS, have not yet reached the prototype stage. This leads to considerable uncertainty concerning the postulated effectiveness of a FOFA strategy, specifically in the ability of the FOFA systems to observe and locate Pact reinforcements as they move from their divisional assembly areas and to destroy vehicles once they have been found.

Additional uncertainty exists concerning the availability of all the components necessary to perform the FOFA mission. The previous analysis assumed that the JSTARS radar and ATACMS missile with antiarmor submunitions would be available by the mid-1990s. Recent developments may place this schedule in jeopardy, however. The JSTARS program has experienced delays in its testing schedule; the first flight test with the radar has slipped six months from spring of 1988 until the fall, at the earliest. The schedule for fielding an antiarmor version of the ATACMS missile also appears to have slipped from the early 1990s to the mid-1990s, at the earliest. (There is no funding for the antiarmor version noted in the Department of Defense program descriptions or other unclassified five-year defense plans.) Furthermore, procurement of the antiarmor warhead for MLRS, which is also a candidate for use on the ATACMS missile, has been delayed two years. As a consequence, it is impossible to predict how much capability NATO will have in 1993 to attack Warsaw Pact follow-on forces.

Locating Targets. The primary means for locating groups of moving combat vehicles will be the JSTARS radar. Some analysts are concerned, however, that JSTARS' capability could be negated. Since the system will be easy to locate because of its size and radar emissions, the opposing forces will obviously know its whereabouts and might attempt to destroy it with fighter aircraft and surface-to-air missiles. Enemy forces could also thwart JSTARS' ability to detect moving combat units by covering their vehicles' radar returns with electronic noise or jamming.

These enemy attacks on JSTARS could be countered to some extent. The JSTARS should have the range to operate from deep within friendly territory, and NATO aircraft could defend JSTARS. In addition, the radar has been designed to negate electronic countermeasures through sophisticated electronic and signal processing techniques. By itself, however, JSTARS would probably not be able to detect all of the pertinent targets all of the time.

Destroying Targets. Once detected, targets must be destroyed. This is also a complex process fraught with risks. To destroy a target, a missile must be programmed to fly to the suspected location of the target and must reach the predicted position without going off course or being shot down. The missile must fly close enough to the correct location so that when it dispenses its submunitions, they will be able to locate individual target vehicles. Finally, the submunition must detonate and inflict sufficient damage on the vehicle to render it ineffective for combat.

As stated previously, this alternative presents a long-term solution, one that cannot benefit NATO before the mid- to late 1990s. Indeed, it may not be possible to purchase the large numbers of ATACMS missiles envisioned here before the early part of the next century. This adds further uncertainty as to when this alternative could improve NATO's position, and underlines the difference in timing between this alternative and the previous three.

Pact Countermeasures to FOFA. Finally, the Warsaw Pact could, by changing its strategy or tactics, attempt to limit FOFA's effect. As evidenced by articles in the Soviet military literature, the Soviet Union has studied the use of both active and passive countermeasures to reduce FOFA's impact.17/ Passive measures include the use of terrain for camouflage and protection from the JSTARS radar, hardening of equipment, and troop dispersion. The Pact could also use decoys such as flares and other deliberately set fires to try and divert infrared

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17. Sally Stoecker, "Soviets Plan Countermeasures to FOFA," *International Defense Review* (November 1986), p. 1608.

submunitions from combat vehicles. The most obvious active countermeasure to FOFA would be to attack ATACMS launchers with conventional artillery.

The extent to which the Warsaw Pact can successfully counter NATO attempts to attack follow-on forces is, of course, also highly uncertain. The fact that Soviet military literature reflects concern regarding NATO's ability to make such attacks, however, points to their potential. Furthermore, any Pact efforts designed to negate FOFA's impact could divert energy from the Pact's primary mission of defeating NATO at the front. FOFA could, therefore, provide some benefit to NATO simply by its potential lethality, even if it did not work as well as predicted.

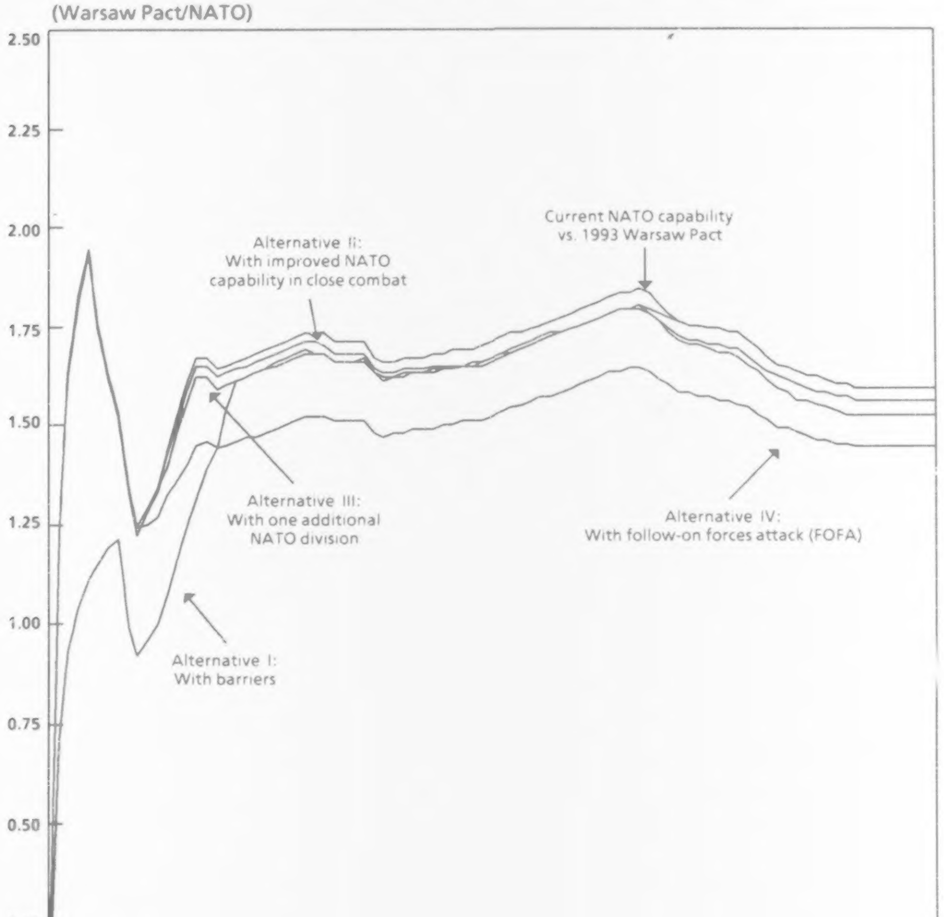
For FOFA to work, then, many separate components have to perform well. Sensors have to detect targets, processors have to locate targets and relay information to weapons, which then have to destroy targets. Because so many system components must all work, and because none of them currently exists, investing in FOFA presents a major risk. Comparison with the other alternatives makes clear, however, that FOFA also offers opportunities for improving the balance of forces in Europe.

COMPARISON OF ALTERNATIVES

If FOFA can be made to work, it offers the greatest payoff under the greatest range of assumptions among the alternatives considered in this study. Sixty days after mobilization, for example, FOFA could improve the Pact/NATO balance of forces by 11 percent (see Figure 18). None of the other alternatives examined here comes close to that level of improvement. Although the FOFA strategy has promise, it is too early to conclude that it is the most cost-effective approach to improving NATO's ground forces.

The option to add barriers (Alternative I) differs from the others in terms of costs and the pattern of benefits. Barriers cost relatively little (see Table 9) and, depending on judgments about their effectiveness, could greatly enhance capability early in a conflict. Barriers add

Figure 18.
Comparison of Force Ratios Under Four Alternatives for Improving NATO Conventional Ground Forces



SOURCE: Congressional Budget Office based on Department of Defense data; John C.F. Tillson IV, "The Forward Defense of Europe," *Military Review* (May 1981), p. 66; and Office of Technology Assessment, *New Technology for NATO: Implementing Follow-On Forces Attack* (OTA-ISC-309, June 1987).

TABLE 9. TOTAL COSTS OF ALTERNATIVES FOR IMPROVING NATO CONVENTIONAL GROUND FORCES
(Costs in billions of fiscal year 1989 dollars of budget authority)

	1989	1990	1991	1992	1993	Subtotal 1989-1993	1994-2008	Total 1989-2008
				Near Term				
Alternative I: Add Barriers	1.0	1.0	1.0	1.0	1.0	5.0	0.0	5.0
Alternative II: Improve Close-Combat Capability	4.6	5.9	7.4	6.9	4.5	29.4	19.1	48.4
Alternative III: Add One Division	5.0	4.5	1.8	1.8	1.8	14.8	26.4	41.2
				Long Term				
Alternative IV: Emphasize Follow-On Forces Attack	0.6	0.8	0.9	1.1	2.4	5.7	44.0	49.7

SOURCE: Derived by the Congressional Budget Office based on data included in Department of Defense publications; John C. F. Tillson IV, "The Forward Defense of Europe," *Military Review* (May 1981), p. 66; Institute for Defense Analyses, *Follow-On Force Attack*, R-302, vol. V (Alexandria, Va.: IDA, April 1986); and Department of the Army, U.S. Army Concepts Analysis Agency, *Forward of the FEBA Weapon System Cost and Benefit Study (FOFEBA), Phase I*, CAA-SR-81-3 (February 1981).

less to capability after the initial days of a conflict as they are destroyed by enemy forces. Nonetheless, their relatively modest costs suggest they would be desirable if political opposition to their installation could be overcome.

Other studies have reached similar conclusions about the merits of FOFA and other approaches for strengthening U.S. ground forces. A recent U.S. Army analysis, for example, concluded that modernizing equipment for close combat would not enable U.S. ground forces to defeat the Warsaw Pact without the capability to attack follow-on forces.18/ That study also concludes that attacking Pact reinforcements enables U.S. forces at the front to perform better because they would not be as badly outnumbered. In addition, the delay imposed by

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18. Brigadier General John C. Bahnsen, USA (Ret.), "The Army's in Third Place--It Better Try Harder!" *Armed Forces Journal International* (May 1987), p. 82.

an attack on reinforcements would allow U.S. and NATO forces to reconsolidate defenses and negate, to some extent, the damage inflicted by the Pact's first-echelon forces.

The FOFA strategy is risky, however, because it relies on unproven weapons designed to attack follow-on forces. To reduce this risk, it might be possible to combine near-term strategies--such as adding barriers, if that is politically possible, or improving close-combat weapons--with continued development of FOFA weapons systems at a pace that is sufficiently slow to allow full testing of FOFA components before making investment decisions. Emphasis could shift to FOFA weapons when and if their feasibility is established. Such an approach would, however, maximize total costs because two or more alternatives would be pursued instead of carrying out just one option to improve conventional ground forces.

APPENDIXES

APPENDIX A

DESCRIPTION OF THE DYNAMIC MODEL USED IN THIS STUDY

The dynamic model used in this study was based on one developed by Joshua M. Epstein of the Brookings Institution.1/ Epstein's model, which attempts to simulate the conduct of a conventional war of attrition, is based on the premise that both the attacker and defender will accept some level of attrition to their forces in an effort to attain some objective. For the attacker, the objective might be to gain territory, and the defender's goal might be to repel the attacker without losing ground. Epstein has assumed, however, that there is some level of attrition beyond which each side is willing to abandon its objective, at least temporarily; that is, when losses become too high, the aggressor might stop pressing the attack. Likewise, the defender might be willing to withdraw to a new position to avoid further losses, at least for the moment.

Epstein attempts to capture these phenomena through mathematical equations describing each side's starting position and losses for each day of a theoretical war. When hostilities begin, each side's total forces can be assigned a numeric value, such as the weapon effectiveness index/weighted unit value (WEI/WUV) score described in Chapter II. In addition, each side might start out with a specific number of ground-attack aircraft with which it can inflict losses on the other side's ground forces. As the war progresses, each side loses ground combat capability and aircraft as determined by the equations Epstein has developed. The defense, in order to maintain its losses at an acceptable level, gives up ground. The mathematical process of removing ground and air assets can continue for a specified number of days or until one side is decimated.

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1. Joshua M. Epstein, *The Calculus of Conventional War: Dynamic Analysis Without Lanchester Theory* (Washington, D.C.: Brookings Institution, 1985).

DETAILED DESCRIPTION

The Congressional Budget Office modified the model, as described in Epstein's 1985 publication, to make it more useful in analyzing the subjects pertinent to this study. In particular, modifications were incorporated to allow the addition of reinforcements and the use of weapons for follow-on forces attack. The model was also expanded to accept attrition rates that vary over the course of the war.

Epstein's model requires the definition of variables and constants, which are listed in Table A-1. Several equations are used to compute each side's losses at the end of each day of combat. Specifically, the equations that govern the conduct of ground combat are:

$$A(t+1) = A(t)[1 - AGL(t)] - ACASL(t)$$

and

$$ATOT(t) = A(t) + AREINF(t).$$

Similarly,

$$D(t+1) = D(t) - \frac{AGL(t)A(t)}{XCHNG(t)} - DCASL(t)$$

and

$$DTOT(t) = D(t) + DREINF(t)$$

where

$$AGL(t) = APROS(t)\left(1 - \frac{W(t)}{WMAX}\right)$$

and

$$W(t) = 0$$

if $DTL(t-1) \leq DMAX$, or

TABLE A-1. VARIABLES AND CONSTANTS USED IN THE DYNAMIC MODEL

Symbol	Definition
	Ground Forces
A(t)	Attacker's ground force value surviving at the start of day t
AREINF(t)	Attacker's reinforcements available on day t
ATOT(t)	Attacker's total ground forces available on day t
APROS(t)	Attacker's prosecution rate on day t
AGL(t)	Attacker's losses to ground combat (measured in attrition rate) on day t
ATL(t)	Attacker's total ground force loss rate on day t, to both air and ground forces
AMAX	Attacker's threshold attrition rate
D(t)	Defender's ground force value surviving at the start of day t
DREINF(t)	Defender's reinforcements available on day t
DTOT(t)	Defender's total ground forces available on day t
XCHNG(t)	Exchange rate for ground combat on day t (that is, attackers lost per defenders lost)
DMAX	Defender's threshold attrition rate
DTL(t)	Defender's total ground force loss rate on day t, to both air and ground forces
W(t)	Defender's rate of withdrawal in kilometers per day
WMAX	Defender's maximum rate of withdrawal in kilometers per day
t	Time in days, $t = 1, 2, 3, \ldots$
	Close Air Support Forces
AAC(t)	Attacker's close air support (CAS) aircraft on day t
AACL	Attacker's CAS aircraft attrition rate per sortie
ASRTY	Attacker's daily sortie rate per CAS aircraft
ASRTYPK	Defender's armored fighting vehicles killed per attacker CAS sortie
ACASL(t)	Attacker's ground forces lost to defender's CAS on day t
DAC(t)	Defender's CAS aircraft on day t
DACL	Defender's CAS aircraft attrition rate per sortie
DSRTY	Defender's daily sortie rate per CAS aircraft
DSRTYPK	Attacker's armored fighting vehicles killed per defender CAS sortie
DCASL(t)	Defender's ground forces lost to attacker's CAS on day t
NUMAFV	Number of armored fighting vehicles per armored division equivalent (ADE)
L	Lethality points (or WEI/WUV score) per ADE

SOURCE: Congressional Budget Office based on Joshua M. Epstein, *The Calculus of Conventional War: Dynamic Analysis Without Lanchester Theory* (Washington, D.C.: Brookings Institution, 1985).

$$W(t) = W(t\text{-}1) + [WMAX - W(t\text{-}1)] \left(\frac{DTL(t\text{-}1) - DMAX}{1\text{-}DMAX}\right)$$

if $DTL(t\text{-}1) > DMAX$.

Furthermore,

$$DTL(t\text{-}1) = \frac{DTOT(t\text{-}1) - D(t)}{DTOT(t\text{-}1)}$$

and

$$XCHNG(t) = 3 - 0.5[ATOT(t)/DTOT(t)]$$

if $ATOT(t)/DTOT(t) < 5.5$, otherwise

$$XCHNG(t) = 0.5.$$

The attacker's daily prosecution rate--denoted by APROS(t)--according to Epstein "represents the rate of attrition to ground combat that the attacker is prepared to suffer in order to press the attack at his chosen pace." By setting $W(1) = 0$ and the first day's prosecution rate, $APROS(1) < AMAX$, then

$$APROS(t) = APROS(t\text{-}1) - \left(\frac{AMAX\text{-}APROS(t\text{-}1)}{AMAX}\right)[ATL(t\text{-}1)\text{-}AMAX]$$

and

$$ATL(t\text{-}1) = \frac{ATOT(t\text{-}1) - A(t)}{ATOT(t\text{-}1)}$$

For the treatment of each side's aircraft and ground losses to the enemy's close air support (CAS) aircraft,

$$DAC(t) = DAC(t-1)(1-DACL)^{DSRTY}$$

and

$$AAC(t) = AAC(t-1)(1-AACL)^{ASRTY}.$$

To determine the daily losses to each side's CAS aircraft,

$$DCASL(t) = \frac{L}{NUMAFV} \; ASRTYPK \bullet AAC(t) \sum_{i=1}^{DSRTY} (1-AACL)^{i-1}$$

and

$$ACASL(t) = \frac{L}{NUMAFV} \; DSRTYPK \bullet DAC(t) \sum_{i=1}^{ASRTY} (1-DACL)^{i-1}.$$

(The model accommodates nonintegral sortie rates by appending an additional term to represent the fractional sortie, for both attacking and defending aircraft.)

The output of the model, of course, depends largely on the values assigned to the variables and constants used in the model. The same initial values and constant values were used for all the dynamic analyses in this study (see Table A-2).

ADVANTAGE OF DYNAMIC MODELS

Dynamic comparisons take into account each side's ability to destroy the other and the effect of attrition over time. Such models, however, require much of the same quantitative information included in static balances--and more. Dynamic comparisons can be viewed as starting where static comparisons end. In addition to counting each side's equipment, dynamic models also simulate the destruction of the opposing side's weapons, depending on the ability of each side's systems to do so. Thus, the ability of each combatant's weapons to find and destroy the enemy's weapons and the rate at which this can be done determine the outcome of a force comparison. In this way, dynamic models can, based on numerous assumptions and inputs, simulate the interaction of many different types of weapons, the impact of different strategies, and the contribution of logistic support.

TABLE A-2. VARIABLES AND VALUES USED IN THE DYNAMIC MODEL

Variable	Value
APROS(1)	2.0 percent
AMAX	7.5 percent
DMAX	5.0 percent
WMAX	20 kilometers per day
DAC(1) a/	330 aircraft
AAC(1) b/	250 aircraft
DSRTY c/	2 sorties per day, 1.1 sorties per day
ASRTY	1 sortie per day
DACL c/	4 percent, 1 percent
AACL c/	4 percent, 1 percent
DSRTYPK	.50 armored fighting vehicles per sortie
ASRTYPK	.25 armored fighting vehicles per sortie
NUMAFV	1,800 armored fighting vehicles per armored division equivalent (ADE)
L	130,458 lethality points per ADE

SOURCE: Congressional Budget Office based on Joshua M. Epstein, *The Calculus of Conventional War: Dynamic Analysis Without Lanchester Theory* (Washington, D.C.: Brookings Institution, 1985); and Department of Defense, Office of the Assistant Secretary for Program Analysis and Evaluation, *NATO Center Region Military Balance Study, 1978-1984* (July 1979).

a. Number of NATO close air support (CAS) aircraft assumed to be assigned to each corps sector facing a main attack.

b. Number of Pact CAS aircraft assigned to each main attack corridor.

c. The two numbers represent the value used for the first week of combat and the value used thereafter, respectively.

Calculation of dynamic balances, however, requires many detailed inputs; many assumptions about the interactions of individual weapons, the general conduct of war, and the mathematical equations governing it; judgments concerning the behavior of commanders on each side; and, generally, large computers to process the numbers. Furthermore, since dynamic assessments of force balance depend on the conduct of war, they are highly dependent on local force concentrations. They are therefore more useful for examining the course of the battle in smaller sectors of the battlefield than across the whole theater. Finally, the outputs of such models typically describe the amount of territory a military unit has ceded to its attacker after so many days of war, or the number of enemy tanks and aircraft destroyed by each side.

Limitations of Dynamic Models

Although dynamic models attempt to quantify and take into account many aspects of war that static balance comparisons do not, they must necessarily rely on many assumptions concerning the conditions under which a war would be fought. Some of these conditions cannot be predicted, thus placing the credibility of such models' outcomes in question. Questions also arise concerning the equations used in the models, whether the model or the scenario is biased for or against a particular side, and the sensitivity of the model to different assumptions. Thus it would appear that a dynamic model may have as many disadvantages as advantages and does not necessarily offer a more reliable method for evaluating relative combat capability than some less sophisticated static models.

Epstein's model, like any quantitative method for evaluating the relationship between two military forces, cannot be used to predict the outcome of an actual conflict. No mathematical model, even one that attempts to capture the dynamics of warfare, can replicate all the factors that determine the course of a battle. Indeed, some factors that have a large impact on the outcome of a conflict--such as leadership, morale, tactical competence--cannot be quantified. Others, such as location of the attack, weather and other conditions at the time of attack, and the element of surprise cannot be predicted.

APPENDIX B

NATO'S EMPHASIS ON SUPPORT STRUCTURE AND ITS EFFECT ON THE BALANCE OF FORCES

Despite the parity in the number of active-duty personnel of NATO and the Warsaw Pact in the central region (1.4 million and 1.2 million, respectively), NATO combat divisions are outnumbered by Warsaw Pact divisions by approximately 1.7 to 1.0. This discrepancy stems primarily from NATO's greater emphasis on support structure and tactical air power.

NATO's ground combat divisions, though they contain roughly the same number of fighting vehicles as Warsaw Pact counterparts, are manned at much higher levels. A typical U.S. armored division has about 16,500 soldiers, whereas a Soviet tank division in eastern Europe would be at full strength with 10,500--or more than one-third fewer--people. A U.S. division would have more people involved in support activities such as vehicle maintenance, ammunition and fuel resupply, and general logistics activities than its Soviet counterpart. This difference in unit size accounts for the greater number of Warsaw Pact combat units, even though the Pact has roughly the same number of people as NATO.

Two basic reasons account for this significant discrepancy in support structure between Pact and NATO forces. The first is a difference in replacement philosophy: the Pact replaces entire units that have been depleted with fresh ones, whereas NATO replaces individuals within units. Second, the Soviet style of administration is much more centralized. Unlike NATO units, which include administrative organizations at all levels, only Soviet and Pact units at higher levels, such as divisions and armies, include large command structures.

Some experts have argued, however, that Warsaw Pact units would not be effective in combat over long periods of time because they lack sufficient logistical support.1/ For example, Pact units might not have the mechanics to fix broken-down vehicles or the supply-truck drivers or handlers to pass forward the necessary food, fuel, and ammunition. One Department of Defense (DoD) study estimated that the Pact might be able to keep its units in intense combat for only five to six days.2/ NATO's combat units, on the other hand, are assumed to be more capable of sustained combat because of their superior support structure. (The same DoD study suggests that U.S. units could maintain intense conflict indefinitely if supply stocks were adequate.) In addition, because each individual NATO unit has its own command structure, the units will be better able to operate independently and flexibly. If the United States and its allies have invested so much of their military capital in support, it is reasonable to believe that NATO's military planners expect a payoff in terms of increased effectiveness in combat.

NATO's greater investment in support structure is not reflected in its armored division equivalent (ADE) scores, however. If increased support results in higher combat effectiveness, then, arguably, NATO's ADE scores should be increased proportionately to reflect that increased efficiency. Some analysts have suggested that efficiencies as high as 50 percent could translate into a 50 percent increase in NATO's ADE score.3/ Such an increase would radically affect the balance of forces (see Figure B-1). Indeed, if NATO's investment in support structure produces a return proportional to its investment in manpower, then under conditions outlined in the middle-range case defined in Chapter II, the Pact/NATO force ratio in the central region would be roughly equal to 1.0 during the 90 days after mobilization. Most important, however, is the fact that NATO's support structure could offset, to some extent, the Warsaw Pact's numerical advantage in combat troops and equipment.

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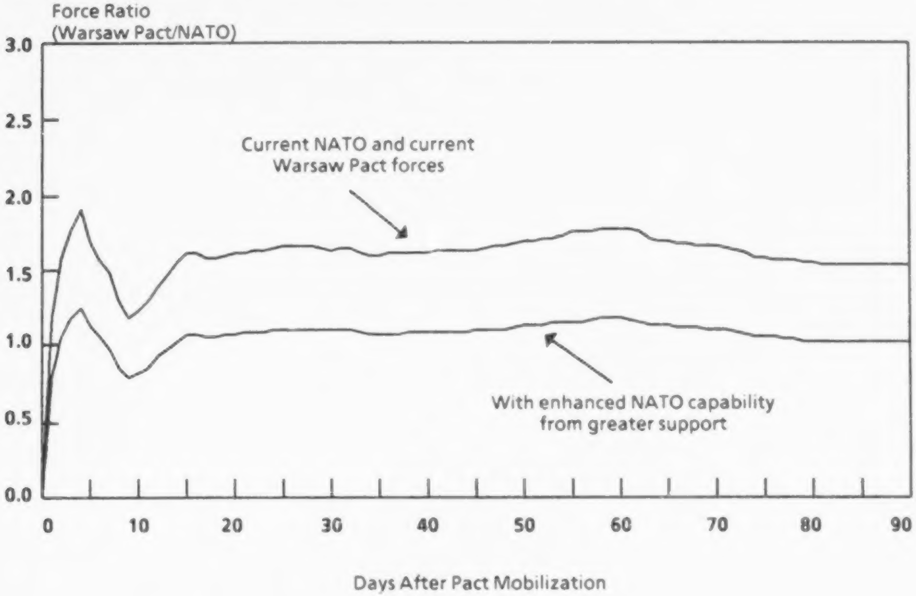
1. See William P. Mako, *U.S. Ground Forces and the Defense of Central Europe* (Washington, D.C.: Brookings Institution, 1983), p. 60.

2. Department of Defense, Office of the Assistant Secretary of Defense for Program Analysis and Evaluation, *NATO Center Region Military Balance Study, 1978-1984* (July 1979), Appendix D, p. 8.

3. Barry R. Posen, "Measuring the European Conventional Balance," *International Security*, vol. 9 (Winter 1984-1985), pp. 66 and 67; and Department of Defense, *NATO Center Region Military Balance Study, 1978-1984*, p. I-22.

Figure B-1.
Potential Effect of NATO's Support Forces on Theaterwide Force Ratios (Middle-range case)



SOURCE: Congressional Budget Office based on Department of Defense data.

Some analysts have suggested that by restructuring its forces, NATO could, with the same manpower, create more combat divisions and thus more evenly match the Pact's combat power.4/ This, of course, would be a drastic departure from NATO's current strategy and structure. If NATO's military planners conclude that their past strategy was wrong and decide to shift support personnel to combat roles and to reorganize NATO along the same line as the Pact's current structure, many more combat divisions could be created.

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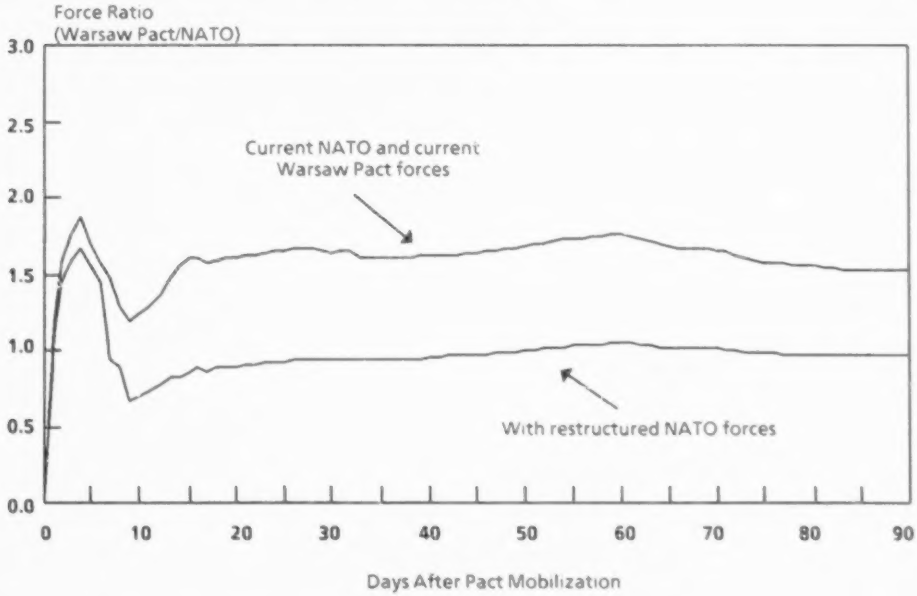
4. William Mako cites several discussions of this kind of restructuring, including those by Steven Canby, *The Alliance and Europe*, part 4: *Military Doctrine and Technology*, Adelphi Paper 109 (London: International Institute for Strategic Studies, 1974), pp. 21-22; William S. Lind, "Some Doctrinal Questions for the United States Army," *Military Review* (March 1977), pp. 54-65; and Edward N. Luttwak, "The American Style of Warfare and the Military Balance," *Survival*, 21 (March-April 1979), pp. 57-60.

Theoretically, NATO countries that currently provide forces to the central region could add 36 heavy combat divisions to their current force structure without increasing the number of soldiers in the ground forces. About half of these new divisions could be fielded by the United States, with one of the additional divisions being formed from the 217,000 Army personnel currently stationed in Europe.

Of course, NATO would need more than people to create new divisions. According to the ADE method of comparison, divisions with personnel and no equipment are worth nothing. The equipment alone for a new heavy division could cost about $3.6 billion; the cost of munitions and reserves of munitions and spare parts could add another $1.4 billion. Furthermore, the additional U.S. divisions based in the States

Figure B-2.
Effect of Restructuring NATO's Forces on Theaterwide Force Ratios (Middle-range case)



SOURCE: Congressional Budget Office based on Department of Defense data.

would be able to reach Europe shortly after mobilization only if each had an additional set of equipment prepositioned in West Germany. This would cost an extra $3.6 billion for each of the 17 divisions formed. Thus, the total cost to the United States alone could be as high as $90 billion to $150 billion, just to buy the equipment, war reserves, munitions, and prepositioned sets for these new divisions; the total cost to NATO could be up to $240 billion.

Creating these new divisions would enable NATO to match the Pact almost 1 to 1 on the basis of combat divisions, with a similar result in the force balance analysis (see Figure B-2 on preceding page). If NATO's investment in support forces has a payoff roughly equivalent to its cost in people, however, then increased capability can be achieved by increased efficiency without expenditures on equipment and added divisions, as was illustrated in Figure B-1.

APPENDIX C

GROUND FORCES AND TACTICAL AIRCRAFT IN THE CENTRAL REGION

Although the countries included in the NATO and Warsaw Pact alliances encompass essentially all of Europe, CBO's study was limited to those forces that would participate in a conflict within the central region. This area includes most of the inter-German border and specifically comprises the Federal Republic of Germany (also referred to as West Germany), Belgium, the Netherlands, Luxembourg, the German Democratic Republic (also known as East Germany), Poland, and Czechoslovakia.

Many other countries currently have forces stationed in the central region, including several NATO members--the United States, Great Britain, and Canada--France, and the Soviet Union. These conventional forces have been the subject of most discussions concerning the Warsaw Pact/NATO balance and will be examined in more detail in this appendix.

GROUND FORCES

Each alliance has large numbers of ground combat units permanently stationed in the central region (see Tables C-1 and C-2). In addition, countries in each alliance, most notably the United States for NATO and the Soviet Union for the Warsaw Pact, are capable of providing large numbers of reinforcing units. The time at which these reinforcing units could be available to either side is a function of many variables, including combat readiness, peacetime location, and the rapidity with which each side starts to mobilize.

Warsaw Pact

Although the Department of Defense, in its publication *Soviet Military Power*, describes all of the Warsaw Pact combat units as being of

TABLE C-1. WARSAW PACT COMBAT DIVISIONS AVAILABLE FOR A CONFLICT IN THE CENTRAL REGION

National Army and Location in Peacetime	Category I Divisions			Category II Divisions			Category III Divisions a/		
	Tank	MRD	Airborne	Tank	MRD	Airborne	Tank	MRD	Total
East Germany	2	4	0	0	0	0	0	0	6
Czechoslovakia	3	3	0	0	0	0	2	2	10
Poland	5	3	0	0	2	2	0	3	15
Soviet Forces in:									
East Germany	11	8	0	0	0	0	0	0	19
Czechoslovakia	2	3	0	0	0	0	0	0	5
Poland	2	0	0	0	0	0	0	0	2
Soviet Union									
Baltic MD	0	0	2	1	3	0	2	2	10
Byelorussian MD	0	1	1	3	1	0	6	0	12
Carpathian MD	1	0	0	1	6	0	0	3	11
Kiev MD	0	0	0	0	0	0	7	4	11
Moscow MD	0	0	1	0	0	0	2	4	7
Ural MD	0	0	0	0	0	0	1	2	3
Volga MD	0	0	0	0	0	0	0	3	3
Central Asian MD	0	0	0	1	1	0	0	5	7
Total	26	22	4	6	13	2	20	28	121

SOURCE: Congressional Budget Office based on data from William P. Mako, *U.S. Ground Forces and the Defense of Central Europe* (Washington, D.C.: Brookings Institution, 1983), p. 44; and Gunter Lippert, "GSFG, Spearhead of the Red Army," *International Defense Review* (May 1987), p. 559.

NOTE: MRD = motorized rifle division; MD = military district.

a. The Warsaw Pact has no Category III airborne divisions in these locations.

"active" status, they are not all maintained at the same level of readiness.1/ Pact divisions are typically divided into three categories, with only Category I divisions actually being kept in "ready" condition. The International Institute for Strategic Studies defines the categories as follows:

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1. Department of Defense, *Soviet Military Power, 1987* (1987), p. 17.

TABLE C-2. NATO COMBAT DIVISIONS AVAILABLE FOR A CONFLICT IN THE CENTRAL REGION

National Affiliation	Divisions a/			
		Reinforcements		
	In Place b/	Active c/	Reserve d/	Total
United States	5 ⅓	10	15	30 ⅓
West Germany	12	0	3 ⅓	15 ⅓
Belgium	⅔	⅔	⅔	2
Canada	⅓	0	0	⅓
Denmark	0	2	0	2
France e/	3	12	0	15
Netherlands	⅓	1 ⅔	1 ⅓	3 ⅓
United Kingdom	3	⅔	0	3 ⅔
Total	24 ⅔	27	20 ⅓	72

SOURCE: Congressional Budget Office based on data from William P. Mako, *U.S. Ground Forces and the Defense of Central Europe* (Washington, D.C.: Brookings Institution, 1983); International Institute for Strategic Studies, *The Military Balance, 1987-1988* (London: IISS, 1987); Department of Defense, Office of the Assistant Secretary of Defense for Program Analysis and Evaluation, *NATO Center Region Military Balance Study, 1978-1984* (July 1979); Diego A. Ruiz Palmer, "Between the Rhine and the Elbe: France and the Conventional Defense of Central Europe," *Comparative Strategy*, vol. 6, no. 4(1987), pp. 489 and 490; and Association of the U.S. Army, "The Total Army at a Glance," *Army* (May 1988).

a. Includes separate brigades and armored cavalry regiments (ACRs). Three brigades or three ACRs are considered equivalent to one division.

b. All of these forces could be available within one to three days after NATO starts to mobilize. A small fraction (about one-eighth) are on constant alert, however, and would be available immediately.

c. All of these forces, except those from the United States, could be available within a week after NATO starts to mobilize. Six of the U.S. divisions would be available within 10 days of NATO's mobilization.

d. The European reserves could be available within one week after NATO starts to mobilize. The last U.S. reserve unit included here would arrive 79 days after mobilization.

e. France, although not a military member of NATO, does have bilateral agreements with West Germany stating that France will come to West Germany's aid if the latter is attacked.

- Category I. Can attain full personnel strength after 24 hours' notice and is fully equipped.

- Category II. Typically at 50 percent to 75 percent personnel strength with complete set of fighting vehicles.

- Category III. Cadre divisions maintained at 20 percent personnel level, possibly with a complete set of combat equipment, though typically of older vintage.2/

The amount of time needed to bring divisions in Categories II and III up to combat-ready status is a much-debated topic. Estimates range from 7 to 30 days for Category II divisions and from 15 to 120 days for Category III divisions.3/ It must be noted, however, that all of the Soviet units stationed in eastern Europe outside of the Soviet Union are maintained at the highest level of readiness. These troops would most likely spearhead any Soviet invasion of central Europe.

NATO

NATO units would also need time to prepare for combat. Of the units permanently stationed in Europe, only a fraction--primarily reconnaissance battalions and cavalry regiments--are maintained on 24-hour alert. The remaining 20 or so divisions would need one to three days to reach full strength and to move from their peacetime locations to positions appropriate for impeding a Pact advance. The European nations could quickly provide 17 reinforcing divisions (within three to seven days), and the United States could provide another six divisions rapidly. These six divisions, though stationed in the United States during peacetime, maintain an extra set of equipment in Europe through a program that prepositions combat equipment in West Germany. This allows the personnel to be flown to Europe, pick up their equipment from special warehouses (a process that takes about a day), and be ready for combat.

The United States can provide an additional four active divisions within 30 days, and 15 reserve divisions theoretically within 79 days after mobilization. During the United States' last experience with a

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2. International Institute for Strategic Studies, *The Military Balance, 1987-1988* (London: IISS. 1987), p. 34.

3. William P. Mako, *U.S. Ground Forces and the Defense of Central Europe* (Washington, D.C.: Brookings Institution, 1983), p. 60; Tom Gervasi, *The Myth of Soviet Military Supremacy* (New York: Harper and Row, 1986); Department of Defense, *Soviet Military Power, 1987* (1987); Secretary of Defense, *Annual Report to the Congress, Fiscal Year 1982* (1981), p. 69; Department of Defense, Office of the Assistant Secretary of Defense for Program Analysis and Evaluation, *NATO Center Region Military Balance Study, 1978-1984* (July 1979), p. I-6.

large-scale mobilization of reserves--in the Korean War--however, mobilization delays were much longer than 79 days. During that conflict, seven months were required to mobilize, equip, and train each reserve division or brigade before it could be sent overseas.[4]

Another factor that will affect the Pact/NATO force balance is the rapidity with which NATO responds to a Pact mobilization. Once Western sources have detected Pact movement to a war status, each NATO country must begin to mobilize its defenses. The time lag between initiation of Pact mobilization and NATO's response to it could have a serious impact on force ratios early in the mobilization process (see Chapter II).

To take into account the wide range of possible conditions that could exist at the start of a conflict between NATO and the Warsaw Pact, CBO examined the force balance in Europe within the context of three scenarios. The scenarios range from one that makes assumptions that favor NATO to one that favors the Warsaw Pact. The scenarios were discussed fully in Chapter II and are defined as follows:

- More Favorable to NATO. NATO responds immediately to a Pact mobilization and begins to mobilize simultaneously. France participates fully in NATO efforts, while Polish and Czech forces do not participate in a Warsaw Pact mobilization. Ninety days are required for all of the divisions from the Soviet central military districts to become combat-ready and reach the front.

- Less Favorable to NATO. NATO does not begin to mobilize until seven days after the Pact mobilizes. France does not contribute forces to NATO, but Polish and Czech forces participate in Warsaw Pact efforts. All Warsaw Pact forces destined for the central region are available within 25 days of the call to mobilize.

- Middle-Range Scenario. NATO mobilizes four days after the Warsaw Pact. France, Poland, and Czechoslovakia participate with their respective alliances. All Warsaw Pact forces are available for combat 60 days after mobilization begins.

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[4] Congressional Budget Office, *Improving the Army Reserves* (November 1985), p. 2.

Additional details about the three scenarios are listed in Table C-3.

TABLE C-3. ASSUMPTIONS MADE IN GENERATING THREE SCENARIOS FOR CONFRONTATION IN THE CENTRAL REGION BETWEEN NATO AND THE WARSAW PACT

Assumption	Scenario More Favorable	 Middle-Range	 Less Favorable
NATO			
French Forces Included	Yes	Yes	No
Mobilization Delay (Days) a/	0	4	7
Warsaw Pact			
Polish and Czech Forces Included	No	Yes	Yes
Arrival of Last Unit in Theater (Days after mobilization)			
Soviet forces in:			
East Germany	7	4	2
Czechoslovakia	7	4	2
Poland	15	4	2
East German forces	7	4	2
Czech forces	n.a.	4, 8 b/	7
Polish forces	n.a.	8	7
Soviet forces			
Western military districts	42	15	15
Central military districts	90	60	25

SOURCE: Congressional Budget Office based on data from William P. Mako, *U.S. Ground Forces and the Defense of Central Europe* (Washington, D.C.: Brookings Institution, 1983); and Department of Defense, Office of the Assistant Secretary of Defense for Program Analysis and Evaluation, *NATO Center Region Military Balance Study, 1978-1984* (July 1979).

NOTE: n.a. = not applicable.

a. Delay between initiation of Warsaw Pact mobilization and start of NATO mobilization.

b. Six of the ten Czech divisions would be available for combat four days after mobilization; the remaining four, four days later.

TABLE C-4. NATO TACTICAL AIRCRAFT IN THE CENTRAL REGION, AT MOBILIZATION AND TEN DAYS LATER

	Fighter-Bombers			Fighters		
	Aircraft	M-Day	M+10	Aircraft	M-Day	M+10
NATO Total		1,498	2,797		586	802
United States	F-111	140	220	F-5E	19	19
	A-10	108	378	F-15C/D	96	312
	F-16A/B	240	408			
	A-7	0	252			
	F-4	24	288			
Total		512	1,546		115	331
Belgium	Mirage 5BA	50	50	F-16A/B	36	36
	F-16A/B	36	36			
Total		86	86		36	36
Canada	CF-18	36	36	n.a.	n.a.	n.a.
Denmark	F-16A/B	24	24	F-16A/B	24	24
	Draken	16	16	Draken	16	16
Total		40	40		40	40
France	Mirage F-IIIE	60	60	Mirage F-1C	120	120
	Mirage F-5F	30	30	Mirage F-IIIC	10	10
	Jaguar-A	24	116	Mirage F-IIIE	15	15
				Mirage F-2000	38	38
Total		114	206		183	183
Germany	F-104G	80	80	F-4F	60	60
	F-4F	60	60			
	Tornado	103	103			
	Alphajet	175	175			
Total		418	418		60	60
Netherlands	F-16A/B	56	56	F-16A/B	56	56
	F-5	49	70			
Total		105	126		56	56
United Kingdom	Tornado	108	180	Tornado	12	12
	Harrier	31	51	Lightning	12	12
	Jaguar	48	108	F-4	72	72
Total		187	339		96	96

SOURCE: Congressional Budget Office using data from Secretary of Defense, *Annual Report to the Congress, Fiscal Year 1983* (1982); International Institute for Strategic Studies, *The Military Balance, 1987-1988* (London: IISS, 1987); The Analytic Sciences Corporation, "Preliminary Atlantic-to-the-Urals Unclassified Conventional Weapon Systems Data Base," Personal communication, Fall 1987.

NOTE: n.a. = not applicable.

TABLE C-5. WARSAW PACT TACTICAL AIRCRAFT IN THE CENTRAL REGION, AT MOBILIZATION AND TEN DAYS LATER

	Fighter-Bombers			Fighters			Interceptors		
	Aircraft	M-Day	M+10	Aircraft	M-Day	M+10	Aircraft	M-Day	M+10
Warsaw Pact Total		1,204	1,249		1,130	1,220		535	795
Soviet Union	MiG-21	45	45	MiG-21	180	180	Su-15	0	90
	MiG-27	405	405	MiG-23	400	445	Su-27	0	45
	Su-17	180	225	MiG-29	155	200	Tu-128	0	35
	Su-24	45	45				MiG-25	0	45
	Su-25	90	90				MiG-31	0	45
Total		765	810		735	825		0	260
Czechoslovakia	MiG-21	30	30	MiG-21	95	95	MiG-21	90	90
	MiG-23	40	40	MiG-23	45	45	MiG-23	45	45
	Su-7	50	50						
	Su-25	25	25						
Total		145	145		140	140		135	135
East Germany	Su-22	40	40	MiG-21	205	205			
	MiG-23	24	24	MiG-23	50	50			
Total		64	64		255	255			
Poland	MiG-17	80	80				MiG-21	292	292
	Su-7	30	30				MiG-23	108	108
	Su-22	120	120						
Total		230	230					400	400

SOURCE: Congressional Budget Office based on data in International Institute for Strategic Studies, *The Military Balance, 1987-1988* (London: IISS, 1987); and The Analytic Sciences Corporation, "Preliminary Atlantic-to-the-Urals Unclassified Conventional Weapon Systems Data Base," Personal communication, Fall 1987.

TACTICAL AIR FORCES

In a European conflict, both sides would have large numbers of tactical aircraft at their command (see Table C-4 on the preceding page and Table C-5 above). Unlike ground forces, aircraft can be readied quickly and transported rapidly from one place to another. Indeed, reinforcing aircraft for both NATO and the Pact should be available within 10 days after mobilization.

In this study, NATO's reinforcing aircraft consisted of 60 U.S. tactical aircraft squadrons based in the United States and Spain during peacetime, plus about 260 additional aircraft from European air forces. All other NATO aircraft are currently based in the central region or Great Britain.

Tallies of the Warsaw Pact aircraft include those permanently stationed in the central region and those assigned to the western and central military districts of the Soviet Union. The interceptor aircraft assigned to the individual national air defenses are also included in these tallies. Although these aircraft would probably not take part in Pact offensive operations into NATO territory, they could be used to counter NATO airstrikes in East Germany, Czechoslovakia, or Poland.

APPENDIX D

SYSTEMS FOR AND ANALYSIS OF FOLLOW-ON FORCES ATTACK

The philosophy behind the postulated NATO strategy of attacking the follow-on forces (FOFA) is to try to prevent an enemy--generally assumed to be the Warsaw Pact--from bringing all of its reinforcing units into the battle area. Specifically, FOFA would attempt to reduce the impact of the Pact's reinforcements by attacking rail lines and bridges in eastern Europe to delay their arrival in theater and by attacking the follow-on or "second-echelon" combat units themselves as they move closer to the front.

DELAY OF FOLLOW-ON FORCES

As stated in Chapter II, more than half of the total Pact forces that would eventually fight in the central European theater are, in peacetime, based in the Soviet Union. To play a role in central Europe, these units would have to travel from their permanent locations in the Soviet Union to the inter-German border. Forces being transported from the Soviet Union by rail must first transfer from broad-gauge Russian trains to narrow-gauge Polish trains at about eight transloading complexes along the Polish border. Subsequently, the major Polish east/west rail lines must cross the Vistula and Dunajec rivers. These few rail lines, the transloading areas, and the rail bridges across the major rivers present opportunities for NATO attacks that could result in significant delays in the transport of reinforcing units.

Current Capability

Targets near the Polish-Soviet border are about 600 to 850 kilometers east of the inter-German border. Aircraft are the only means that NATO has today for attacking railways in this region. NATO's current inventory of tactical aircraft, however, does not include any that can reach the region near the Polish-Soviet border from their bases in England or Germany. (This statement is based on the assumption that the aircraft would carry both ground-attack and self-defense ordnance, would not be refueled, and would fly a profile designed to evade enemy air defenses.) Indeed, data provided by the Air Force to the Office of Technology Assessment (OTA) for a study of the feasibility of the FOFA strategy indicate that current aircraft can barely reach targets inside Poland.

Figure D-1 portrays the maximum distances that current U.S. fighter-bombers can travel to targets when carrying realistic loads of ordnance and self-protective gear and have enough fuel to return to their home bases. (The assumed payloads include 4,000 pounds of ground-attack munitions and self-defense weapons and are listed in Table D-1.) Furthermore, the combat radii portrayed in the figure assume that the aircraft fly at high altitude, which consumes less fuel, only when far removed from enemy air defenses. Any flight over West German or enemy territory is assumed to be at low altitude (200 feet) and 480 knots in order to avoid enemy air defense radars. Only F-111F aircraft, currently based in England, or F-15E aircraft based in Germany have the range to attack targets within Poland and return to base, and no U.S. tactical aircraft could attack targets along the Polish-Soviet border under the conditions outlined above.

Future Capability

At least two studies have concluded that strategic aircraft carrying air-launched, conventionally armed cruise missiles could perform the mission of destroying bridges and rail lines in eastern Europe.1/ In particular, a RAND study postulated the use of existing B-52 bomber aircraft to deliver conventional air-launched cruise missiles for just this mission. That study also speculated that cruise missiles capable of cutting enemy rail lines could be available within five years.

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1. See Stephen T. Hosmer and Glenn A. Kent, *The Military and Political Potential of Conventionally Armed Heavy Bombers*, R-3508-AF (Santa Monica: RAND Corporation, August 1987); and Office of Technology Assessment, *New Technology for NATO: Implementing Follow-On Forces Attack* (OTA-ISC-309, June 1987).

Impact of Delaying Reinforcements

If attacks on the few bridges that cross the Vistula River were successful, they could delay the arrival of the last Soviet unit at the front by 9 to 15 days. Once damaged, railroad bridges are much more difficult to repair than bridges that carry roads, because the tracks must be precisely aligned. Furthermore, since the equipment for the reinforcing Soviet units will, at this distance from the inter-German border, be loaded onto rail cars, temporary bridging and ferries would not provide the Warsaw Pact with an efficient means for their transport across major rivers. If each coordinated cruise missile attack closes the bridges for three days, then three to five successive attacks during the mobilization period could result in 9 to 15 days of bridge closure and delay.

The Polish and East German rail networks would also be attacked by cruise missiles once every three days after the initial attack to prevent repair. Theoretically, by simultaneously derailing the locomotive and cutting the rails, delays of 18 to 24 hours could be imposed per attack. During a 60-day mobilization period, up to 20 attacks could be made at three-day intervals. Thus, if each attack caused 0.75 to 1.0 day of delay, 20 attacks could cause a delay of 15 to 20 days. When added to the 9 to 15 days of delay caused by the damaged bridges, a total delay of 24 to 35 days could be imposed on the arrival of the last Soviet unit at the front.

This study took a very conservative approach toward the total delay that could realistically be imposed by attacks on the Polish transportation network and assumed a total delay of 21 days. The effect of such a delay would be to slip the completion of Pact mobilization from 60 days to 81 days from its initiation. An increase in total mobilization time from 60 to 81 days would reduce the arrival rate of Warsaw Pact reinforcing units at the front from an average of one division every 1.5 days to about one division every 2.1 days.2/ Though subjec-

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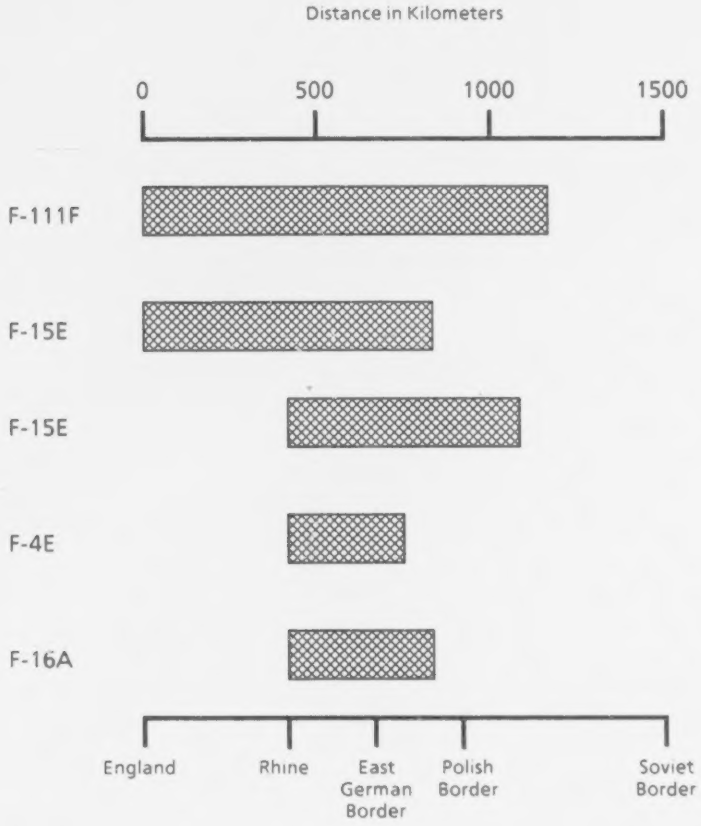
2. The impact of attacks on the eastern European rail network would be, to some extent, a function of when the attacks were initiated. If they did not begin until 15 days after the Pact started to mobilize, as was assumed here, most of the units from Poland and Czechoslovakia would already be in theater, and only those forces from the central military districts of the Soviet Union would still be in transit.

Figure D-1.
Combat Radii of U.S. Fighter-Bomber Aircraft



SOURCE: Office of Technology Assessment, *Technologies for NATO's Follow-On Forces Attack Concept* (July 1986).

NOTE: The radii reflect the maximum distances that current U.S. fighter-bombers can travel to targets and have enough fuel to return to their bases. These radii are based on illustrative payloads shown in Table D-1 and flight at low altitude over West Germany and eastern Europe.

TABLE D-1. ASSUMED LOADS FOR U.S. FIGHTER-BOMBER AIRCRAFT

Aircraft	Self-Defense Weapons a/	Ground-Attack Weapons b/	Miscellaneous Equipment
F-111F	2 Sidewinder missiles	2 Mk-84 bombs	ECM pod PAVE TACK target designation pod
F-15E	2 Sidewinder missiles 2 AMRAAM missiles	2 Mk-84 bombs	LANTIRN navigation and targeting pod 3 external fuel tanks 2 conformal fuel tanks
F-4E	2 Sparrow missiles	2 Mk-84 bombs	ECM pod 2 external fuel tanks
F-16A	2 Sidewinder missiles	2 Mk-84 bombs	ECM pod 2 external fuel tanks

SOURCE: Congressional Budget Office using data from Office of Technology Assessment, *Technologies for NATO's Follow-On Forces Attack Concept* (July 1986).

NOTE: The assumed loads are meant to place the range comparisons on a common basis, not to represent the preferred ordnance for actually attacking follow-on forces.

ECM = electronic countermeasures; AMRAAM = advanced medium-range, air-to-air missile; LANTIRN = low-altitude navigation and targeting infrared for night.

a. Air-to-air missiles.

b. The payload for each aircraft includes 4,000 pounds of ground-attack ordnance.

tive, these estimates are based on previous analyses conducted by respected analytic organizations such as the Institute for Defense Analyses.[3]

Theaterwide Capability. This delay could have a noticeable effect on the balance of forces (see Figure D-2). At a point 60 days after mobilization, for example, the ratio of Pact to NATO forces could be reduced by about 8 percent.

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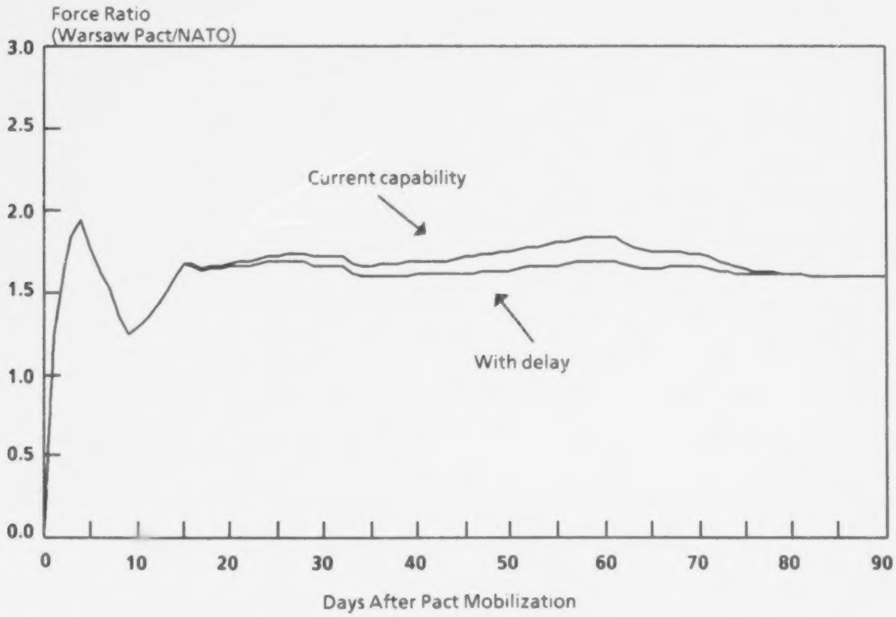
[3] Institute for Defense Analyses, *Follow-On Force Attack*, R-302 (Alexandria, Va.: IDA, April 1986).

Corps Capability. In an already strong corps, such as the U.S. V Corps, the effect of the delay imposed by FOFA tends to have the same magnitude as the effect on the entire theater. (In analyzing results in a particular corps, a dynamic assessment was used. See Appendix A for a description of the dynamic model.)

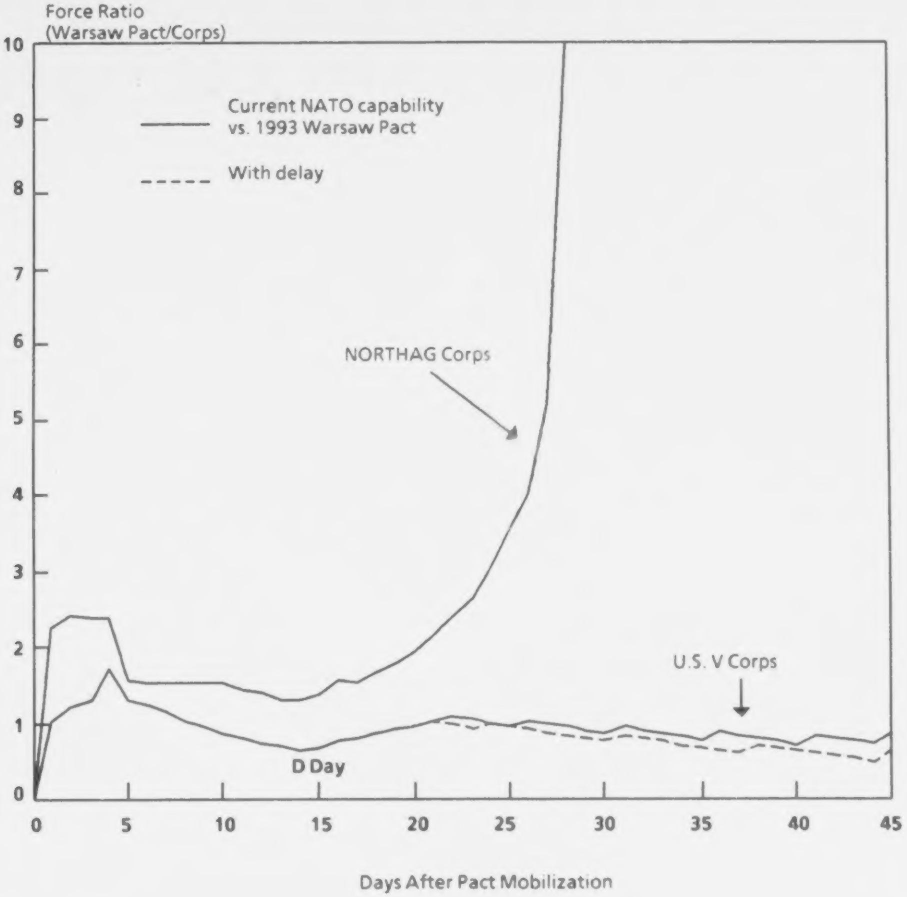
In those corps areas where the Pact currently seems to hold a considerable advantage, however, the story may be different. In the British I Corps or West German I Corps in the Northern Army Group (NORTHAG), for example, this strategy offers little improvement (see Figure D-3). Indeed, the dynamic analyses suggest that attacking the follow-on Pact forces is beneficial only if NATO can thwart the initial attack. If the initial forces cannot be stopped, attack of follow-on forces might be irrelevant.

Figure D-2.
Effect of Delay on Theaterwide Force Ratios



SOURCE: Congressional Budget Office based on Department of Defense data and on Office of Technology Assessment, *New Technology for NATO: Implementing Follow-On Forces Attack* (OTA-ISC-309, June 1987).

Figure D-3.
Simulated Effect of Delay on Force Ratios in Two NATO Corps



SOURCE: Congressional Budget Office based on Department of Defense data and on Office of Technology Assessment, *New Technology for NATO: Implementing Follow-On Forces Attack* (OTA-ISC-309, June 1987).

NOTE: Delay results in no improvement in the corps in NORTHAG.

DESTRUCTION OF FOLLOW-ON FORCES

FOFA may also be able to destroy some of the Pact reinforcing units before they arrive at the front. Pact reinforcing divisions would be attacked during their move from divisional assembly areas, located about 80 kilometers from the forward edge of the battle area (FEBA), to regimental assembly areas, located about 30 kilometers from the forward edge. This move should take about six to eight hours for an entire division traveling over existing roads. Each division would move in about 55 small units or columns with about 60 vehicles in each column. Although NATO's sensors might not be able to detect each of the 55 columns as it moves from one assembly area to another (a process that would take about 1.5 to 3.0 hours for each column), the entire process would probably not go undetected for six to eight hours. This analysis assumes, therefore, that most of the columns from each division would be detected as they move from the divisional to regimental assembly areas.

Current Capability for Detection and Attack of Reinforcing Pact Divisions

NATO and the United States now have some limited capacity to detect and attack Pact second-echelon divisions as they move closer to the front. Neither the detection nor the attack systems that are available today are well suited for the task, however.

The U.S. Army and Air Force each have airborne sensors that can detect ground targets. These sensors include the Army's OV-1D Mohawk system and the Air Force's Advanced Synthetic Aperture Radar System II (ASARS II) radar on the TR-1 aircraft. Both systems have characteristics that make them unsuited for the FOFA mission. The OV-1D's range is not sufficient to detect moving enemy units out to 80 kilometers beyond the FEBA without exposing itself to enemy air defenses, and the ASARS II is better suited for detection of stationary targets. These two systems, however, could find some of the Pact's reinforcing columns as they proceed toward the front.

NATO's only current means for attacking enemy reinforcing units, once detected, would be tactical aircraft armed with bombs or standoff missiles, but the price of using those aircraft to carry out this mission might be high. According to a report by the Office of Technology Assessment, NATO has 1,000 aircraft theoretically available for interdiction missions.4/ Many of these aircraft, however, have other missions in conventional war, including attack of enemy airfields, attack of enemy forces in direct combat with NATO troops (known as close air support), and attack of enemy command posts. Some aircraft may also be held in reserve to deliver nuclear weapons should hostilities escalate to that level. Moreover, losses of aircraft that attempt to attack reinforcing units could be high. Aircraft on such missions would have to penetrate up to 80 kilometers behind enemy lines and fly close to enemy combat units, each of which has its own air defense weapons. A recent study by the Institute for Defense Analyses (IDA) postulated loss rates of 13 percent per mission, which could be prohibitive for carrying out the FOFA mission.5/ Even if loss rates were substantially lower, commanders might not wish to use such expensive assets to attack reinforcing units.

Future Capability to Detect and Destroy Reinforcing Units

The Joint Surveillance and Target Attack Radar System (JSTARS), currently being developed jointly by the Army and the Air Force, is designed to find and track moving targets on the ground up to 300 kilometers beyond the forward edge of battle. The radar, as currently designed, will be mounted on a military version of a Boeing 707 aircraft. To provide continuous coverage of the entire area along the inter-German border, the Air Force plans to keep three JSTARS airborne at all times.

To destroy enemy reinforcements once they have been detected, the Army is developing the Army Tactical Missile System (ATACMS). ATACMS is a ballistic missile that would be launched from the same launcher as that used for the existing Multiple Launch Rocket System (MLRS). The missile would fly to a selected point above the target where it would dispense its submunitions. The initial version of ATACMS missiles will carry antipersonnel and antimateriel submunitions that are not effective against armored vehicles. An improved version, scheduled for production some time after the mid-1990s,

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4. Office of Technology Assessment, *New Technology for NATO*, p. 137.

5. The IDA study is summarized in OTA, *New Technology for NATO*, p. 213.

would carry antiarmor submunitions that are guided to their targets by infrared or millimeter wave sensors.[6]

ATACMS missiles would be directed at those relatively small Pact columns (55 to a division) that are detected by JSTARS or other NATO sensors. Most of these columns, each of which has 60 vehicles, would consist entirely of trucks. Twenty-five or so, however, would each include about 30 combat vehicles such as tanks, armored personnel carriers, and artillery pieces. As currently designed, however, the JSTARS radar, or any other NATO sensor, would probably not be able to distinguish between trucks and armored vehicles. Attacks by these missiles would therefore have to be allotted to *all* reinforcing columns, since NATO would not be able to attack only those with high-value combat vehicles.

Several schemes could be envisioned for targeting each reinforcing Pact division. Each 60-vehicle column will stretch two to four kilometers and will probably be divided into about six company-sized units with 10 vehicles each. Companies will travel with a distance of 25 to 50 meters between vehicles and will, therefore, cover 250 to 500 meters of road surface. The submunitions within each ATACMS missile should be able to cover a segment of road approximately 800 meters long, and so one missile could be allotted to each company-sized unit, resulting in six missiles per column.[7] Thus, each missile--carrying approximately 16 to 20 submunitions--would be allocated to 10 vehicles, resulting in an average of two submunitions per vehicle. This is a relatively conservative allotment of resources.

Based on these assumptions, a targeting scheme of six missiles per column was assumed as a basis for the analysis in this study. Since not all of the vehicles within a given division would be detected, this is actually an average allocation scheme. It assumes that some company-sized units would not be attacked at all, but that others might receive more than one missile.

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6. Infrared sensors detect heat emitted from objects such as tank engines. Millimeter wave sensors are radars that emit radio waves with wavelengths of a few millimeters and then detect their reflection from metal objects such as tanks.

7. James A. Tegnelia, "Emerging Technology for Conventional Deterrence," *International Defense Review* (May 1985), p. 644.

By allotting one ATACMS missile to each company-sized unit within each reinforcing Pact division, 330 ATACMS would be launched at each division during the six to eight hours that it moves from its divisional to regimental assembly areas. Opposite each NATO corps, there may be at most one divisional move per day. Thus, each U.S. corps would need to attack only one Pact reinforcing division per day. The 27 MLRS launchers assigned to each U.S. corps, therefore, would be required to launch 330 ATACMS missiles during the six- to eight-hour period of a divisional move, necessitating that each MLRS launcher fire slightly more than 12 ATACMS missiles in six to eight hours. One ATACMS missile will be loaded into each of the two pods on an MLRS launcher; each launcher would then have to be reloaded six times during that period--a feasible task, since MLRS launchers were designed to be reloaded rapidly.

The overall impact of attacking a reinforcing division with 330 ATACMS is a function of the effectiveness of each missile. The Army has not yet decided on the ultimate configuration of the antiarmor ATACMS. Each missile might carry as few as 16 large submunitions or as many as 96 smaller bombs. Furthermore, few unclassified estimates of the ultimate effectiveness of an antiarmor ATACMS missile are available. One assessment, by the Institute for Defense Analyses, concluded that an ATACMS missile loaded with 20 of the larger submunitions could destroy between three and seven vehicles.8/ At this level of effectiveness, a FOFA attack of 330 ATACMS missiles could destroy between 990 and 2,310 vehicles in each enemy division attacked. Another, more conservative, analysis by Steven Canby, however, estimated that an ATACMS missile is more likely to destroy between one-half and three vehicles.9/ This more pessimistic view stemmed from considering all the things that might go wrong, and assuming that they do. At this level of effectiveness, 330 ATACMS missiles would destroy between 165 and 990 vehicles.

Because the JSTARS sensor may not be able to distinguish between trucks and armored vehicles, and since only 25 percent of a division's vehicles are armored combat vehicles, only a quarter of the

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8. Institute for Defense Analyses, *Follow-On Force Attack*, vol. I, p. III-4.

9. Steven L. Canby, "The Operational Limits of Emerging Technology," *International Defense Review* (June 1985), p. 878.

vehicles destroyed by ATACMS missiles would be combat vehicles. Using IDA's higher estimate of missile effectiveness, this would represent the destruction of between 247 and 578 combat vehicles per division, or 30 percent to 70 percent of a division's combat power. Based on Canby's estimates, however, an attack by 330 ATACMS missiles would result in destruction of only 5 percent to 30 percent of a Pact division's combat capability. Inasmuch as this study attempted to weigh the value of FOFA versus other alternatives, CBO used the more conservative range of capabilities (represented by Canby's analysis) as a basis for estimating the capability of each ATACMS missile. Thus, an average of 20 percent loss of combat capability was assumed to result in each Pact division subject to attack by 330 ATACMS missiles.

The actual impact of FOFA, theaterwide, is a function not only of how well the weapons and supporting sensors work, but also how the Warsaw Pact structures and schedules its attack. If the Warsaw Pact were to attack West Germany shortly after it started to mobilize--say, within four days--then many reinforcing Pact units would still be in transit at the onset of hostilities. Indeed, in the middle-range scenario discussed in Chapter II, 59 Pact divisions could be attacked before they reached the front during the first 30 days of combat if attacks of follow-on forces started four days after the Warsaw Pact began to mobilize (M+4). If attacks continued until all reinforcing Pact units arrived at the front (M+81), then 24 additional Pact divisions would come under attack.

Even if the Pact waits until more of its forces have arrived in theater to initiate hostilities--for instance, 15 days after mobilization (or M+15)--opportunities still exist for deep attack of almost 31 Pact divisions. Many analysts believe, however, that even with those forces in theater, the Warsaw Pact will structure an attack in waves or echelons, holding a significant portion of their forces in reserve and away from the front lines. Using the distribution of Pact divisions previously postulated by the Department of Defense in a 1979 study, this could allow NATO to attack 70 reinforcing Pact divisions, even if attacks were not initiated until M+15.[10] Fifty-three of these reinforcing divisions could be attacked during the first 30 days of combat. This last attack structure, starting at M+15 and conducted in waves or echelons, is the basis for most of the analysis discussed in Chapter III.

Risks

Actually achieving a high rate of destruction among enemy units is a complex process fraught with risks. The missile must fly long distances to the actual position of the intended target. Since the data relay and missile flight out to 80 kilometers within enemy territory could take several minutes, the target position must be continuously updated or predicted from the target's last known location, direction, and speed. Depending on the type of sensor, each submunition will be able to "search" only a limited amount of ground after it is dispensed from the ATACMS missile from a height of several hundred meters. The missile must therefore arrive close enough to the target so that when it dispenses its submunitions, they will be able to locate individual enemy vehicles. As the submunition falls to the ground (usually slowed by a small parachute or umbrella-like structure), its sensor attempts to detect the heat from a tank engine or a radar return from the vehicle itself, depending on the type of submunition. Once a target is detected, the submunition glides toward it and explodes on impact. If it detects nothing, the submunition falls to the ground.

It is unlikely that all of the submunitions carried by a particular ATACMS missile will find individual vehicles to attack as they fall. Indeed, the missile carrying the submunitions could be so far off course that none of the submunitions will find targets. Furthermore, there have been very few tests to date of such missiles and their submunitions. Moreover, none of the tests has been conducted in realistic conditions similar to those that would be found in combat in Europe.

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[10] This distribution would assume that the Warsaw Pact would put only one ADE (or approximately 1.7 Pact divisions) up front for every 11 kilometers of front in the main corridors of attack. All other reinforcing units would be held in successive echelons. See Department of Defense, Office of the Assistant Secretary of Defense for Program Analysis and Evaluation, *NATO Center Region Military Balance Study, 1978-1984* (July 1979).

SELECTED WEAPONS SYSTEMS

Included in the following sections are descriptions of selected weapons systems used by NATO and the Warsaw Pact.

AIRCRAFT

A-10. The A-10 was developed by the United States specifically for the close air support mission. It is heavily armored and incorporates many features to enhance its survivability in the high-threat area over the battlefield. The aircraft has a 30-millimeter (mm) gun for attacking tanks and other armored vehicles and can carry up to 16,000 pounds of bombs and missiles. A-10s were last bought in 1982, and the bulk of the inventory is now about eight years old.

B-52. The B-52 is currently the backbone of the United States' strategic bomber force. First flown in 1952, the last B-52 was produced in 1962. Powered by eight engines and carrying a crew of six, the B-52's maximum speed is 1,050 kilometers per hour. The remaining B-52s are being reconfigured to carry cruise missiles, rather than gravity bombs.

F-4. The F-4 is a two-seat, twin-engine, supersonic aircraft capable of performing both air-to-air and air-to-ground missions. It was originally designed for the Navy, which received its first F-4 in 1960. The F-4 was later also bought by the U.S. Air Force, which eventually procured five models of the aircraft (about 2,300 combat aircraft and 500 reconnaissance planes). About 1,160 combat aircraft are still in the Air Force inventory.

F-15. The F-15 is a twin-engine, single-seat aircraft designed specifically for high maneuverability in air-to-air combat. It is the U.S. Air Force's most sophisticated fighter aircraft and is equipped with advanced radar that allows it to perform its mission in day or night and under all weather conditions. A new version, the F-15E, will be able to perform ground-attack as well as air-to-air missions and will first be fielded in 1989.

F-16. The F-16 was developed in the late 1970s. A comparatively small aircraft, with only one engine and only one seat in the cockpit, the F-16 is considered a "swing-role" aircraft, performing both air-to-air and ground-attack missions for the U.S. Air Force. It lacks the range to perform the deep interdiction mission, however, and does not have the advanced avionics necessary to operate at night or in bad weather. Nonetheless, the F-16 can perform the ground-attack missions of battlefield interdiction and close air support.

F-111. The F-111 is devoted exclusively to ground attack. It has movable or "variable geometry" wings that optimize its aerodynamic shape under different flight conditions. The aircraft is equipped with a radar system for bombing and also with automatic terrain-following radar that allows the pilot to fly at low altitude without being able to see the ground. These advanced avionics allow the aircraft to carry out its mission at night or in foul weather. The last production model was delivered to the U.S. Air Force in 1976.

MiG-21 Fishbed. The MiG-21, one of the most widely used fighters in the world, was developed in the mid-1950s. This single-seat jet aircraft can fly at speeds up to 2,230 kilometers per hour and has a combat radius of 370 kilometers when carrying four 550-pound bombs. Approximately 700 MiG-21s are still in service with the Soviet tactical air forces.

MiG-23 Flogger. First deployed with the Soviet air forces in large numbers in 1973, this variable-geometry aircraft is currently in service with all Warsaw Pact air forces. The MiG-23 has a maximum speed of 2,500 kilometers per hour and a combat radius of 900 to 1,200 kilometers. Approximately 1,780 Floggers were serving with the Soviet air forces in 1986.

Su-22 Fitter. This variable-geometry, ground-attack aircraft was first seen as a prototype in Moscow in 1967 and has since been exported to Poland and Czechoslovakia for fielding with their air forces. The Su-22 can fly at speeds up to 2,200 kilometers per hour and has a combat radius of 250 to 345 kilometers.

Su-25 Frogfoot. The Frogfoot is the Soviet counterpart to the U.S. A-10 close air support aircraft. Although a few of these aircraft were deployed to Afghanistan in 1982, the Su-25 did not reach full operational capability until 1984. This two-engine, single-seat aircraft can fly at speeds up to 880 kilometers per hour and has a combat radius of 556 kilometers.

AIR DEFENSE

Air Defense Antitank System. Designed in Switzerland, ADATS is a missile system that is being fielded with Canadian and U.S. forces. The U.S. version is carried on a lightly armored, tracked vehicle. ADATS is designed primarily to destroy aircraft and helicopters, but can also engage tanks and other armored vehicles. Each ADATS launcher includes a target-finding radar and an optical tracking system. The ADATS missile has an effective range of eight kilometers. The development test phase was completed in mid-1984.

Division Air Defense Gun. Production of the DIVAD began in 1982 but was terminated in August 1985. Designed to provide the U.S. Army's forward combat units with low-altitude air defense coverage, the DIVAD gun was scheduled to replace the current Vulcan air defense gun. Whereas the Vulcan has a 20mm gun with an effective range of 1,200 meters, the DIVAD included twin 40mm guns with an effective range of 4,000 meters.

Vulcan. The Vulcan air defense system, first introduced into U.S. Army units in 1968, consists of a six-barrel 20mm "Gatling" gun. Its effectiveness is limited to good weather conditions and a range of 1,200 meters. In armored divisions, the Vulcan is mounted on a lightly armored carrier; in other units, it is towed.

ARTILLERY

Howitzers

M109 155mm Howitzer. The M109 howitzer has been in service with the U.S. Army since 1963. The 155mm cannon is mounted on an aluminum-armored, tracked vehicle that carries a crew of six. The

M109 can fire up to one round every minute continuously for periods as long as an hour; its maximum range is 18 kilometers. The vehicle has a maximum road speed of 55 kilometers per hour and a cruising range of 350 kilometers.

M110 8-inch Howitzer. Developed by the U.S. Army starting in the late 1950s, the M110, in various versions, is in service with many of NATO's armies, including those of the United States, Belgium, West Germany, Greece, Italy, the Netherlands, Spain, Turkey, and the United Kingdom. The A1 version, which is widely fielded with the U.S. Army, has an 8-inch gun that is mounted on a tracked vehicle with a maximum road speed of 56 kilometers per hour and a cruising range of 725 kilometers. The crew of five can fire up to 30 rounds per hour, with a maximum range of 20,600 meters.

2S1 122mm Howitzer. First fielded with Soviet and Polish forces in the early 1970s, the 2S1 howitzer is mounted on a tracked vehicle with a maximum road speed of 60 kilometers per hour. Carrying a crew of four, the 2S1 can fire up to three rounds per minute for prolonged periods of time to a maximum range of 15,300 meters. This howitzer is currently fielded with all Warsaw Pact armies in the European central region.

2S3 152mm Howitzer. The 2S3 howitzer includes a 152mm cannon that is mounted on a tracked vehicle and has a maximum firing range of 24 kilometers. It entered service with the Soviet forces in the early 1970s and is currently also fielded with the East German army. The howitzer's crew of three to six can fire two rounds per minute over a sustained period.

Multiple Rocket Launchers

Multiple Launch Rocket System. The MLRS is an artillery rocket system designed to counter enemy artillery and air defenses. Each rocket can carry hundreds of small cluster munitions. The MLRS was initially fielded in U.S. Army units in early 1983.

BM-21 122mm Multiple Rocket Launcher. First seen publicly in Moscow in 1964, the BM-21 has since become the Soviet army's standard multiple rocket launcher. Mounted on a standard truck chassis, the BM-21 has 40 launch tubes arranged in four rows. A 40-rocket salvo can be fired in a few seconds. Each rocket has a range of 20,500 meters, and the entire launcher can be reloaded in 10 minutes.

Mortars

M224 60mm Lightweight Company Mortar. This mortar, designed specifically for use by U.S. infantry companies, can be set up and fired by a single soldier without assistance. Weighing only 46.5 pounds, it can fire charges to a maximum range of 3,490 meters. The U.S. Army has fielded more than 1,590 of these mortars.

M252 81mm Mortar. This medium-range (up to 5,600 meters) mortar will replace the older version--the M29 81mm mortar--currently fielded with the U.S. light infantry, airborne, and air assault divisions. The mortar, which weighs 91 pounds, is operated by a crew of five and can fire up to 15 rounds per minute. The United States started buying the M252 in 1985 and began fielding it two years later.

M30 107mm Mortar. The M30 is no longer in production but is still fielded with U.S. mechanized infantry units and armored cavalry regiments. A heavy--almost 700 pounds--weapon that can be hand-carried for only short distances when broken down into five pieces, the M30 can lob rounds out to ranges of 6,800 meters. The Army has expressed interest in developing a lighter 120mm mortar to replace it.

M-1937 82mm Mortar. The M-1937 is widely fielded with most Warsaw Pact armies. The mortar weighs 123 pounds and it can be towed behind a truck or armored personnel carrier. The M-1937 requires a crew of five to operate it, and it can lob 15 to 25 rounds per minute to a maximum range of 3,040 meters.

M-1943 120mm Mortar. The M-1943 has been the standard mortar in the Soviet forces since World War II. Six mortars are currently deployed with each motorized rifle battalion. A crew of six operates this 606-pound mortar, which can be towed behind a truck or armored personnel carrier. A sustained firing rate of up to 100 rounds per hour can be maintained over long periods of time, while a maximum rate of 12 to 15 rounds per minute is possible for short periods. The maximum range of the M-1943 is 5,700 meters.

HELICOPTERS

AH-1S Cobra Helicopter. The AH-1G Cobra saw extensive combat duty in Vietnam as an attack helicopter. The latest version, the AH-1S, is equipped with TOW missiles, rockets, and a 20mm machine gun. Unlike the more modern AH-64, the AH-1S is limited primarily to operating in fair weather.

AH-64 Apache Helicopter. The Apache is the U.S. Army's most modern attack helicopter and permits its crew of two to attack in darkness and in adverse weather. The AH-64 carries 16 Hellfire antitank missiles, which can home in on a target designated by a laser beam. The AH-64 also carries a 30mm gun and 2.75-inch rockets. Production began in 1982, with procurement of 675 AH-64s planned through 1989.

HIND E. A Soviet-built attack helicopter, the HIND E is equipped with a large-caliber machine gun and 57mm rockets. It is believed to carry, in addition, up to four antitank missiles with a range of eight kilometers. The HIND helicopter has been deployed since 1974 in Warsaw Pact armies.

MISSILES

Antitank--Launched from Aircraft

Hellfire Missile. Designed to be carried on the AH-64 helicopter, the Hellfire homes in on a target that has been designated by a laser beam; this designation can be made by other aircraft as well as by ground observers. Current plans call for a "follow-on seeker" that will permit the missile to find its target without any external designation--a "fire and forget" capability.

Maverick Air-to-Surface Missile System. The Maverick is a precision-guided, tactical missile for use against hardened targets such as tanks, armored vehicles, and field fortifications. The latest version, carried by the U.S. Air Force's F-16 aircraft, is guided to its target by heat emissions.

Tube-Launched, Optically Tracked, Wire-Guided (TOW) Antitank Missile. Carried on the Bradley fighting vehicle, the AH-1S attack helicopter, and the improved TOW vehicle, the TOW missile's warhead can penetrate the front--where the armor is generally the thickest--of the majority of the world's main battle tanks. It has an effective range of 3,750 meters. Once launched, it must be guided by a gunner, who maintains the cross hairs of the sight on the target. As the gunner tracks the target, a computer in the launcher sends corrections to the missile through fine wires. The TOW missile has been in the Army's inventory for many years; current plans call for improvements in the lethality of the warhead to ensure the weapon's effectiveness into the 1990s.

Antitank--Medium-Range, Ground-Launched

Bill Antitank Missile. The Bill is a wire-guided, command-to-line-of-sight weapon--similar to the Dragon and Milan (see below)--with an effective range of 150 to 2,000 meters. The Bill is unique, however, in that it flies slightly above its intended target and fires a slug downward toward the top of the enemy tank. Since the armor protection is usually thinner on the top of a tank, Bill's angled warhead is claimed to give the missile a higher kill probability. It was initially fielded in Sweden in 1986.

Dragon. The Dragon is a medium-range, wire-guided, antitank missile light enough to be carried by a soldier. It has an effective range of 1,000 meters. Once launched, it must be guided by the gunner, who maintains the sight on the target. As the gunner tracks the target, a computer in the launcher sends corrections to the missile through fine wires. The Dragon is deployed in Army units and is no longer in production.

Milan. The Milan is a wire-guided, antitank missile system that can be carried by two soldiers. The improved version, Milan 2, incorporates a guidance system similar to that of the Dragon, which requires the gunner to maintain the cross hairs of the sight on the target during the missile's flight. It has an effective range of 2,000 meters and was first fielded in the early 1970s.

Antitank--Short-Range, Ground-Launched

AT-4. The AT-4 is a recently developed, shoulder-fired, antitank weapon that the U.S. Army is buying to replace the Light Antitank Weapon (LAW) in some of its units. Originally designed in Sweden, the AT-4 has a bigger and heavier warhead than the LAW and is therefore able to penetrate an additional 145 millimeters of armor plate.

Light Antitank Weapon. The LAW is the U.S. Army's most widely fielded modern version of the World War II bazooka. It is a one-shot, low-cost, shoulder-fired antitank weapon with an effective range of 300 meters.

Other Missiles

Army Tactical Missile System. The ATACMS is a U.S. system designed for deep attack of enemy forces at a range beyond that of current rockets and artillery. The ATACMS is a ballistic missile to be fired from a modified MLRS (Multiple Launch Rocket System) launcher. The missile will use an inertial system to guide it accurately to the area where submunitions will be dispensed from the warhead section. The current version will carry small dual-purpose bombs that are effective against both personnel and equipment. A later version will carry submunitions that are capable of destroying armored vehicles. Formally started in 1983 as the Joint Tactical Missile System (JTACMS), the project combined earlier programs carried out separately by the Army and the Air Force. In mid-1984, the Air Force ended its participation, and the Army continued the program and changed the name. Production of the first version will start in 1989.

Cruise Missiles. The U.S. cruise missile program includes the air-launched cruise missile (ALCM), the ground-launched cruise missile (GLCM), and the sea-launched cruise missile (SLCM). The ALCM provides the Air Force with an air-launched strategic weapon for deployment on the B-52 and B-1 bombers. The ALCM, which was initially fielded in 1982, is intended for high-speed cruise flight at low altitudes for distances of up to 2,500 kilometers. The GLCM consists of a cruise missile incorporated in a ground launcher mounted on a truck. It has an effective range of 2,500 kilometers and can be used for nuclear attacks on fixed targets such as logistics facilities and airfields. The GLCM was initially fielded in 1984, but all versions are due to be destroyed under the terms of the Intermediate-Range Nuclear Forces Treaty. SLCMs are designed for launch from submerged submarines or from surface ships. Designed for both land attack and antiship missions, the SLCM uses either nuclear or conventional high-explosive warheads and different guidance systems, depending on the mission. Its ground-attack range is 2,500 kilometers, while that of the antiship version is 450 kilometers. It was initially fielded in 1984.

SURVEILLANCE SYSTEMS

Advanced Synthetic Aperture Radar System II. The Air Force's ASARS II is a high-resolution radar designed to detect stationary objects on the ground. It can be carried by the TR-1 aircraft (described below).

Joint Surveillance and Target Attack Radar System. A battle management and targeting system, JSTARS is a joint program of the Air Force and Army. The radar is mounted on a military version of a Boeing 707 and is intended to detect enemy vehicles on the battlefield. The entire system--which includes the radar, on-board operators' consoles, and ground stations--is designed to direct attacks against moving ground targets by low-flying aircraft and missiles. The radar's detection range is expected to be up to 300 kilometers into the enemy's territory. JSTARS is currently in full-scale engineering development.

OV-1D (Mohawk) Surveillance System. The OV-1D is a two-seat, twin-turboprop, combat aircraft equipped with side-looking airborne radar and photographic or infrared sensors capable of monitoring enemy operations in daylight, darkness, and adverse weather.

TR-1 Aircraft. The TR-1 is a small single-engine aircraft designed to carry reconnaissance payloads such as photographic equipment or radars. It is designed to fly at very high altitudes for long periods of time and is a modified tactical version of the well-known U-2 aircraft.

TANKS

M1/M1A1 Abrams Tank. The Abrams tank is the U.S. Army's premier battle tank. Both versions of the M1 are equipped with special armor, a laser rangefinder, and a 1,500-horsepower turbine engine. The M1A1, which is now being produced, incorporates a 120mm main gun that has a higher muzzle velocity and longer range than the original 105mm version on the M1. The Army purchased about 3,270 M1 tanks equipped with the smaller gun. About 1,900 M1A1s have been produced so far, with 2,700 more planned by the mid-1990s.

M60A1/M60A3 Tank. The M60A1 tank was first deployed in the early 1960s and was later followed by an improved version, designated the M60A3. Enhancements to the M60A1 that are included in the M60A3 are a laser rangefinder and a solid-state fire control computer. These two models account for the bulk of U.S. tanks currently deployed with Army units. Production of the M60A3 tank was completed in 1983, and the United States has no plans to produce more.

Chieftain Tank. The Chieftain is the most prevalent tank in the British army, 900 having been produced between 1963 and the early 1970s. The tank is equipped with a 120mm gun, weighs 61 tons, and has a maximum road speed of 48 kilometers per hour. The fire control system has undergone several improvements since the tank was first designed in the early 1960s.

T-64 Tank. First fielded with Soviet units in 1967, the T-64 was in production through the early 1980s. Almost 11,500 T-64 tanks, in various versions, are assumed to be in service today. The T-64 is equipped with a 125mm cannon, weighs 42 tons, and has a maximum road speed of 70 kilometers per hour.

T-72 Tank. The T-72 entered production in 1971 and is simpler in design and production requirements than the T-64. As a consequence, the T-72 has been widely fielded with non-Soviet Warsaw Pact forces, whereas the T-64 is found exclusively in Soviet units. Also equipped with a 125mm gun, the T-72, at 45 tons, weighs more than the T-64 and has a slightly slower maximum road speed of 60 kilometers per hour. Approximately 8,100 T-72s are currently believed to be in service throughout the Warsaw Pact.

T-80 Tank. The latest version of the Soviet (hence Warsaw Pact) main battle tank, the T-80, will replace the current T-72 built in the early 1970s and the T-64 built even earlier. The T-80 is believed to have a 125mm main gun, an automatic loader, and a laser rangefinder. The T-80's special armor may be the major improvement of this tank, relative to the T-72.

VEHICLES AND ARMORED PERSONNEL CARRIERS

Bradley Fighting Vehicle. The Bradley fighting vehicle is the U.S. Army's latest armored personnel carrier. It includes a two-person turret with a 25mm cannon mounted on a lightly armored, tracked chassis. The Bradley also carries a TOW antitank guided missile launcher. Initial production began in 1980.

M113. The M113 is an aluminum-armored personnel carrier designed to transport troops, equipment, and cargo during combat operations. It can carry 11 soldiers at a maximum cross-country speed of 30 kilometers per hour. The only armament carried on the M113, which entered production in 1960, is a 50-caliber (12.7mm) machine gun. The U.S. Army currently owns more than 26,000 of these vehicles.

Ferret Reconnaissance Vehicle. The Ferret is a wheeled, lightly armored reconnaissance vehicle in service with the British Army. It carries a crew of two or three and can be equipped with various kinds of light armament. The first model was produced in 1952, and the last of more than 4,400 Ferrets was delivered in 1971.

BMP. A Soviet-built armored fighting vehicle, the BMP is equipped with a 73mm automatically loaded gun that will fire a high-explosive antitank round. The BMP has been in production since the late 1960s, and it is deployed in significant numbers in Warsaw Pact armies.

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